8-1990

Non-Insulin Dependent (Type II Diabetes) in the Eastern Cherokee

Patricia Ann Quiggins
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a dissertation written by Patricia Ann Quiggins entitled "Non-Insulin Dependent (Type II Diabetes) in the Eastern Cherokee." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

Richard L. Jantz, Major Professor

We have read this dissertation and recommend its acceptance:

Mary Ann Bass, Tim Aldrich, Michael Logan, Benita Howell

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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NON-INSULIN DEPENDENT (TYPE II) DIABETES MELLITUS IN THE EASTERN CHEROKEE OF WESTERN NORTH CAROLINA

A Dissertation

Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Patricia Ann Quiggins

August 1990

ACKNOWLEDGEMENTS

The author wishes to express her sincere appreciation to Dr. Mary Anne Farrell of the Indian Health Service, Nashville Area Office, at Cherokee, N.C., for providing diabetes data used in this dissertation. Her graciousness and good humor contributed more to the completion of this dissertation than she probably realizes. When undertaking a project such as this in unfamiliar surroundings one is always indebted to those offering hospitality and companionship. Thus, I am indebted to a long list of people at Cherokee. I hope I will be able to so as much for them someday.

Appreciation is also due members of my dissertation committee for their support and encouragement throughout this undertaking. I am indebted to all of them for different reasons: Dr. Richard Jantz for many thoughtful comments and statistical know-how, Dr. Benita Howell for practical advice on all sorts of matters, Dr. Mary Ann Bass for introducing me to the Cherokee community, Dr. Michael Logan for suggesting the Cherokee work, and to Dr. Tim Aldrich for teaching me the basics of epidemiology and how to enjoy doing it.

Although not an official committee member, Dr. John Finger of the Department of History was an invaluable resource person, providing data and references not easily available otherwise. In addition, thanks are due Dr. EmÖke Szathmary for her generosity in providing me with reprints of her publications and for being a good listener.

Several others outside the academic community have encouraged and assisted me along the way and their efforts deserve acknowledgement as well. Dr. and Mrs. Edward Von Halle provided me with pleasant company and the use of their computer during the final stages of writing. Fellow graduate students Brett Riggs, Betty Duggan, Hank McKelway, and David Hunt participated in hours of fruitful discussions on Cherokee matters.

Finally, I wish to thank my family, both nuclear and extended, for their patience during my pursuit of the Ph.D.

ABSTRACT

Type II (Non-insulin dependent) diabetes is a serious problem for the Eastern Cherokee affecting 8% of the total population and 25% of the population over the age of 35 years. However, there have been no published epidemiological data on diabetes among the Eastern Cherokee since 1965. This study describes the current (1988) epidemiology of diabetes in the Eastern Cherokee population calculated from Indian Health Service Data, compares these rates to the U.S. general population, and examines demographic, cultural, and social factors that affect distribution of diabetes among the Cherokee.

Diabetes was determined to be most common in individuals ages forty-five years and older and among individuals whose degree of Indian inheritance is 75% or more. Although socioeconomic indicators were not available for individual persons, diabetes occurs most frequently in Indian populations residing in North Carolina counties having the greatest number of Indian families with incomes below poverty level.

Comparison of data from the 1924 Baker Roll to the present enrollment shows the current population to be older and have a higher average degree of Indian inheritance. Assortative mating by blood degree resulted in a bimodal pattern of blood degree among Baker enrollees that has been reinforced by social and historical circumstances. The age distribution of the current diabetic cases shows that most of the current diabetic individuals were born when the population was clearly divided according to blood degree. Similar processes may have contributed to diabetes in other tribes and need to be taken into account in comparing diabetes prevalence rates.

Implications of the epidemiological findings for the Eastern Cherokee are discussed, as are other studies that would further enhance understanding of diabetes in this and other Native American populations.

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CHAPTER I

INTRODUCTION AND PURPOSE OF STUDY

1. INTRODUCTION

Diabetes is a serious problem for the Eastern Cherokee, accounting for an amputation rate two to three times the incidence rate of the U. S. diabetic population and twice that of the Indian Health Service (Farrell et al. 1989). Additional complications such as end-stage renal disease, retinopathy, and cardiovascular problems are prevalent to the extent that they cause disability to those affected and strain health care services. Nearly all (603 of 606 cases in 1988) diabetes in the Eastern Cherokee is Type II, or non-insulin dependent diabetes mellitus (NIDDM) (ibid.). In this dissertation the term "diabetes" refers to Type II disease unless otherwise noted.

The research described here is concerned with the prevalence and distribution of adult-onset diabetes mellitus among the Eastern Band of Cherokee Indians. Prevalence rates describe the number of cases of a particular disease present during a specified period. Because they are indications of the disease burden in the population, they are most often used by health care administrators in planning and delivering health services. Incidence rates, on the other hand, describe the probability of a given number of new cases occurring in a population at risk. These rates are most useful in comparing rates between specific groups, because they are not affected by disease duration. In order to ascertain incidence, it is necessary to know the onset of a disease, or the date it was diagnosed. This study is restricted to prevalence because onset is not recorded for over two-thirds of the diabetic patients using the Indian Health Service at

Cherokee. Certain methodological problems related to determining diabetes prevalence (as well as rates for other conditions) in heterogenous Indian populations, such as the Eastern Cherokee, are discussed.

A study of diabetes among the Eastern Cherokee done during the 1960s described by Stein, et al. (1965), was one of the first to suggest that diabetes might be more prevalent among American Indians than among the general population of Whites in the U.S. Since that time many studies have been undertaken to examine the genetic and environmental aspects of diabetes among American Indians, the most well-known being a long-term study of the Gila River Pima (cf. Sievers and Fisher 1985 and Szathmary 1987 for reviews). Since 1965, when Stein's research was first published, there has been no other study of diabetes among the Eastern Cherokee, although there have been five concerned with obesity and food intake, which are a major risk factors for diabetes (Story, et al. 1986; Terry 1982; Terry and Bass 1984; Tompkins 1980; Driscoll 1982). This study cannot replicate Stein's because the present one is based on Indian Health Service data, which include only those treated for the disease. What it does, however, is provide a picture of diabetes at one point in time that can serve as a baseline for examining trends in prevalence over the next few years.

This study also examines diabetes prevalence from a broader perspective than Stein's study, incorporating socioeconomic variables. Furthermore, it is possible to examine variation in prevalence within the various geographic areas in which the Eastern Cherokee live, since there are population data available for each township and for Cherokee County Indians.

While the compilation of statistics on diabetes prevalence may seem to be more the purview of the epidemiologist, anthropological methods prove valuable for interpreting and utilizing epidemiological findings. In the Introduction to Anthropology and Epidemiology: Interdisciplinary Approaches to the Study of Health and Disease (1986), Frederick Dunn and

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Craig R. Janes describe several analytical differences between anthropology and epidemiology. Of particular importance here is the difference in the focus of data collection, with anthropologists being more inclined to study "...'bounded' groups of people: communities, villages, and cultures" (ibid. p. 11). Epidemiologists, on the other hand, are generally concerned with "...large population aggregates identified in terms of geographic, administrative, or demographic boundaries" (ibid.). The unit of analysis in the present study includes the members of the Eastern Band of Cherokee Indians, a fairly large aggregate population, and standard epidemiological methods are used to determine diabetes prevalence. But the inclusion of other contextual data, makes the study more anthropological. Dunn and Janes note that while anthropologists are more interested in the social and cultural context of illness and disease,

> ...There is no assumption in epidemiology that members of groups under scrutiny are related to each other, or see themselves related to each other, in any way other than as defined by the epidemiologist (i.e. being a member of a specific ethnic, sex, age, or residential group (1986:7).

Nonetheless, anthropologists and epidemiologist are still asking the same basic questions:

> (1) what are the social, behavioral, demographic, and biological characteristics of persons who develop disease; (2) what is the relationship of the disease to geographic, ecological and social locales; and (3) what is the relationship of disease onset to specific risk factors (ibid. p. 8).

These elements are all parts of what Dunn and Janes call the "causal assemblage" of the disease - "...complexes of environmental, host-biological, and host-behavioral factors...." They use the example of coronary heart disease to show how anthropologists examine these causal assemblages in order to provide additional knowledge about the disease:

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> ...Epidemiological attention has for many years been directed to the study of such risk factors as excess body weight, cigarette smoking, sedentary occupations, limited physical exercise, high blood pressure, certain diets, certain personality types, and conditions contributing to sociocultural or psychological stress. Interest has centered on the correlation between each factor and the disease -- or mortality due to the disease. The relative strengths of most of these associations are now well established, at least for some populations in industrialized countries. Little attention, however, has been given to the types and strengths of associations within groups or clusters of these determinants; and few epidemiologist have any incentive to explore how these determinants may be linked to other factors that appear to be quite outside the field of concern of a heart disease researcher (e.g. social structure, social networks, ethnic identity, community organization). It is here that opportunities are open for investigations that may be rewarding for anthropology. We suggest that anthropologists look into these associations not as further contributions to coronary disease epidemiology, but for their own sake, exploring links and relationships no more improbable than those between African agriculture practices, the sickle cell trait, and Anopheles gambiae mosquito behavior would have seemed thirty years ago (ibid. p. 23).

In the present study, ethnohistoric and archaeological studies provide data on demographics and interactions between various subgroups in the population. These sources are especially important in determining whether processes such as population bottlenecks and founder effect may have played a role in maintaining a genotype predisposing certain population segments to diabetes. Equally important are certain cultural factors that may affect mating patterns, e.g. dialect differences or perceptions about "full-blood" and "mixed-blood" categories. Thus knowledge of the cultural and social environment, as well as of Cherokee history, may provide clues to understanding why diabetes occurs in the pattern in which it does.

2. RESEARCH GOALS

This research has four goals:

1. To describe the epidemiology of diabetes mellitus in the Eastern Band of Cherokee Indians with respect to standard demographic variables, i.e. age, sex, degree of Indian inheritance and residence.

2. To compare rates of diabetes mellitus to those of other tribes and to the U.S. general population in order to determine whether the Cherokee data differ significantly from them.

3. To determine whether the population has changed significantly since World War II, when the increase in American Indian diabetes is said to have taken place. Changes in both age and blood quantum distributions would affect the number of individuals at greatest risk for developing diabetes.

4. To identify and describe various cultural and social factors, as well as historical events, that may have served to create and maintain the observed epidemiological pattern, particularly those that may have preserved a "thrifty gene" in this population.

3. SIGNIFICANCE

It is important to study diabetes among the Cherokee for several reasons. First of all, there has been no other study of diabetes prevalence in this group since Stein's, so it is not known whether the disease is more or less common now than at the time of Stein's work. In addition, there has been a considerable growth in research on the disease among Native Americans since 1965, so at present there are useful comparative data. Another reason for pursuing this research is that knowledge about the etiology and clinical course of diabetes has expanded tremendously since the 1960s so that there is much better evidence on which to base hypotheses concerning its persistence in Native American populations. Finally, and perhaps most importantly, epidemiological data presented here are important to the Indian Health Service and to the Cherokee people for obtaining resources to combat diabetes in the Cherokee community.

CHAPTER II

STUDY POPULATION AND RESEARCH METHODS

1. STUDY POPULATION

General Description

The Eastern Cherokee represent that portion of the Cherokee Nation that remained in the east when the majority of the Nation was forced to move west to Indian Territory during Removal in 1838. The 1835 Henderson Roll taken prior to Removal listed some 16,542 Cherokees living east of the Mississippi River. The first enumeration of the Eastern Band after Removal in 1848, the Mullay Roll, listed only 1,517 persons (Litton 1940). Subsequent migrations west further reduced the remaining population after the famous "Trail of Tears" in 1838, primarily in response to political and social events described below.

Today the Eastern Band of Cherokee Indians reside primarily in Jackson, Swain, Graham, Haywood, and Cherokee counties, North Carolina. Most Band members live on or near more than 56,000 acres of federally protected reservation land, most of which consists of Qualla Boundary and the nearby "3200 Acre Tract" in Swain and Jackson Counties. The remainder of reservation land exists in scattered parcels west of the main reservation near Robbinsville in Graham County and Murphy in Cherokee County. At the end of 1987, there were 9,370 individuals on the tribal roll, although the 1980 census lists only 4,822 individuals living on reservation land. The tribe disputes the census figures, believing the reservation population, as well as the number of Cherokees living nearby, to be greatly underenumerated.

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Politically, eastern Cherokee territory was originally divided into five townships: Yellowhill, Painttown, Wolftown, Birdtown, Big Cove. The purchase of Graham County Indian land by the Eastern Band in 1850 added the community of Snowbird (Finger 1984:121) which was later given two votes on the council. Cherokees in Cherokee County (Tomotla) only have been recently recognized as being eligible for membership on the tribal council after a period of considerable controversy, much of which centered on whether residents were really "Indian" (Neely 1976). Each of the first five townships elect two members to represent them on the tribal council, while Snowbird and Tomotla elect one each.

Although it may be only an approximation of genetic diversity, the current roll includes individuals with degrees of Indian inheritance ranging from 1/128 to full-blood. However, tribal policy now allows only those individuals who are 1/16 or more Cherokee as calculated from degrees of inheritance of ancestors on the 1931 Baker Roll (Baker 1931) to enroll (Eastern Band of Cherokee Indians 1982). The Baker Roll has been a subject of controversy because it was taken in anticipation of allotment, and it was said that a number of individuals used various illegal means to enroll so that they could obtain title to plots of land. In fact, over 1,200 individuals, most having less than 1/32 inheritance, had their enrollment contested by the tribe, but their enrollment was upheld by the Bureau of Indian Affairs. In this study the age and inheritance distribution of the Baker Roll population is compared to the age and inheritance distribution of the contemporary population in order to see if changes occurred that might contribute at least partially to the increase in diabetes prevalence since before World War II.

Social diversity is reflected to some degree in census statistics for counties containing a significant Indian population. Most of the Indian population is concentrated in Jackson and Swain Counties on or near Qualla Boundary. However, there are rather significant differences in the Indian populations of the two counties. For example, the Jackson County population is much younger, with over 60% of its population being under 30 years of age (see figure Figure 1). This pattern roughly follows that of the White population of the county, except in the less than 10-year- old age group. In contrast, Swain County's Indian population is more evenly distributed with less than 5% of its population being less than 10 years old (see Figure 2). Interestingly, the Indian age distribution in Swain County is much different from that of the White population, with the latter being more like that of Jackson County.

With respect to socioeconomic diversity, census data show that the percentage of Indian families having incomes below poverty level is roughly the same in Jackson and Swain Counties (no data are available for the other counties), yet there is greater disparity between Indians and Whites in this regard in Jackson County. These data are provided in Table I, Table II.

A special census report on American Indians, Eskimos, and historic areas of Oklahoma shows considerable variation in poverty status among Cherokees living on reservation land. This data are provided in Table I, Table II.

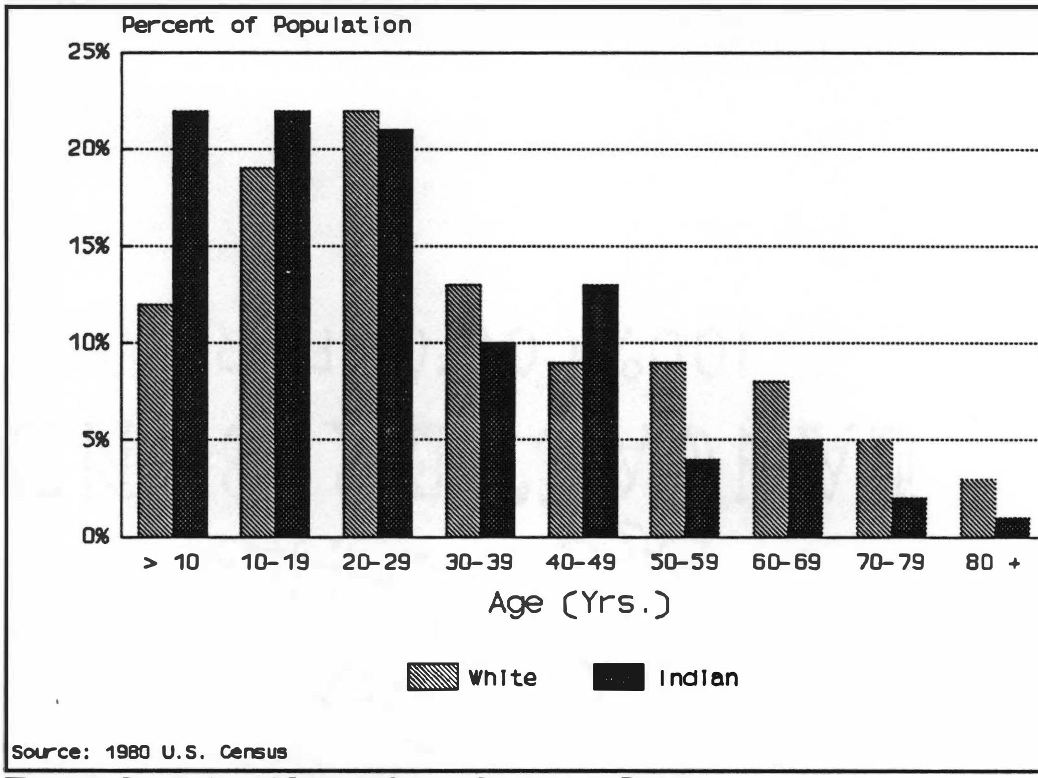

Figure 1 Population of Jackson County, By Age and Race

Source: 1980 U.S. Census of Population

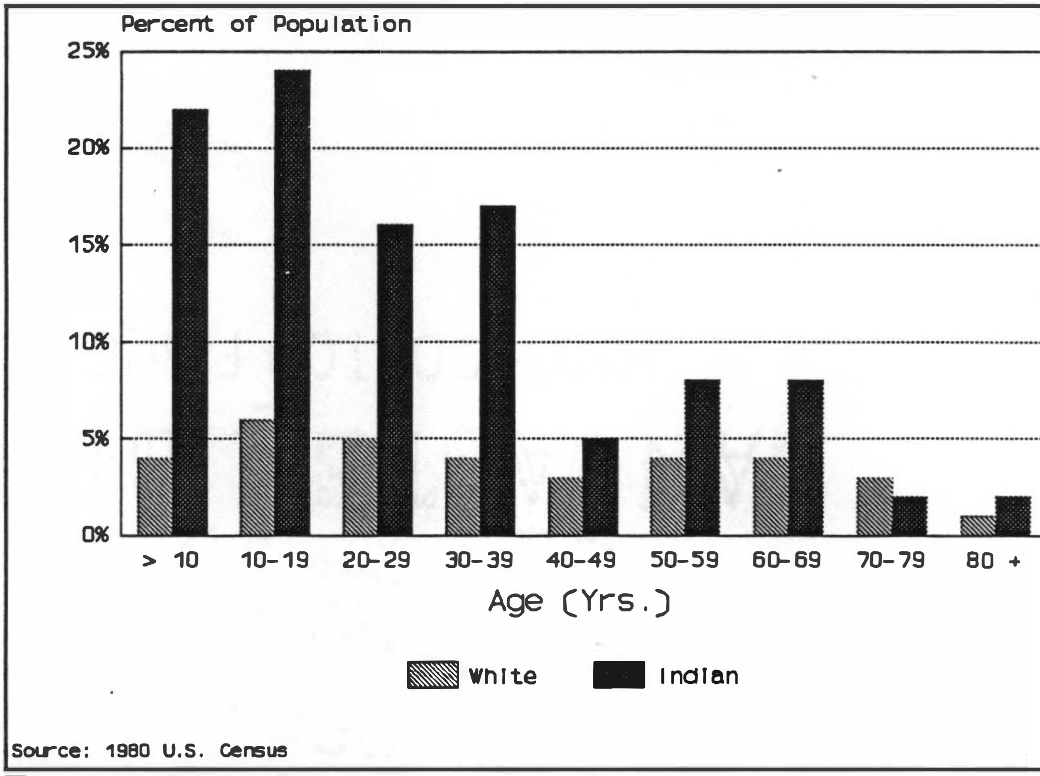

Figure 2 Population of Swain County, by Age and Race

Source: 1980 U.S. Census of Population

Table I Percentage of Families Below Poverty Level: Jackson and Swain Counties, by Race

County	% White Families	% Indian Families	Difference
Jackson	13.2	29.5	16.3
Swain	22.2	28.3	6.1

Table II Percentage of Families Below Poverty Level: Eastern Cherokee Reservation, By County

Location	% Families with Incomes Below Poverty Level 1979
Eastern Cherokee Reservation	32.7
Cherokee County	9.8
Graham County	46.3
Jackson County	32.7
Swain County	32.2

Source: 1980 Census of American Indians, Eskimos, and Aleuts on Identified Reservations and in the Historic Areas of Oklahoma (Excluding Urban Areas)

For comparative purposes, poverty statistics (by race) for the state of North Carolina are provided in Table III, which shows more than three times as many North Carolina Indians to as White families below poverty level, but a slightly lower percentage than Blacks.

Health Services

Five North Carolina counties - Cherokee, Graham, Haywood, Jackson and Swain - make up the Indian Health Service (IHS) service area, the largest population of Indians residing in Swain County (2,493) (1980 U.S. Census). Not surprisingly, Swain County also has the largest proportion Indians in its total population (see Figure 3).

The Indian Health Service operates two health facilities on the reservation, a 35-bed inpatient and outpatient facility in Cherokee and an outpatient clinic at Snowbird. Users of these facilities receive basic services for most health-related problems, including mental health and dental services, but certain conditions requiring specialized diagnostic or treatment procedures are referred to other area facilities. For example, prenatal care is provided by IHS medical personnel, but women must be delivered by an obstetrician at another nearby hospital, usually in Sylva. Patients with diabetes are followed by IHS physicians for routine monitoring and care, but some diagnostic procedures and treatment are provided by, or in consultation with, specialists elsewhere. Thus, an opthamologist in Asheville (60 miles east) provides eye examinations and laser treatments for retinopathy, and amputations are usually performed at the Swain County Hospital in Sylva. Most of the time, consulting physicians provide IHS physicians with results of laboratory tests and any diagnostic procedures, as well as descriptions of treatments provided, and their diagnoses and prognoses. These documents are included in the individual's IHS medical record. In these cases, providers are reimbursed by IHS

Table III Percentage of Families Below Poverty Level: North Carolina, by Place and Race

	% Families Below Poverty Level		
Race	State	Rural	Urban
White	7.6	5.1	8.9
Black	27.1	26.1	28.4
American Indian	25.3	24.3	25.6

Source: 1980 U.S. Census of Population

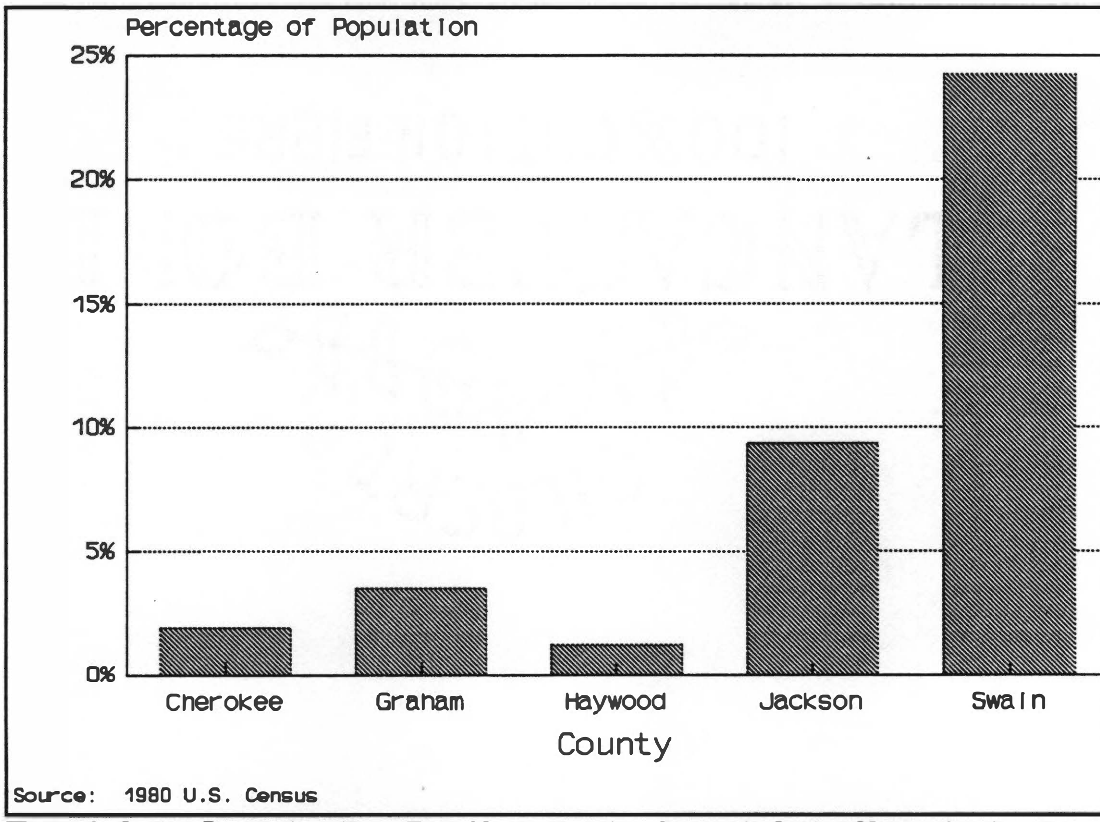

Figure 3 Indian Population (%): Each North Carolina County in Indian Health Service Area

Source: 1980 U.S. Census of Population

Contract Care funds, the patient's private insurer (if privately insured) and/or Medicaid, if the patient is eligible. Some conditions occur in sufficient numbers that specialized clinics are held at Cherokee, but are staffed by specialists from the surrounding area, e.g. a urologists and nephrologists travel from Asheville to hold regularly scheduled clinics at Cherokee.

Eligibility for service at the IHS hospital is based on tribal enrollment or (since 1984) on proof of Indian ancestry, which at Cherokee means having an ancestor on the Baker Roll. All an individual must do to obtain health service is request the enrollment office to investigate his claim and upon receiving a letter of confirmation, present the letter to personnel at the Health Service. Therefore, a great many more individuals are eligible for health services than are actually enrolled, or than appear on the 1980 census. Individuals who are descendants of persons on the Baker Roll, but are not enrolled members are certainly less than 1/32 or 1/16 Cherokee (depending on their ages), and are probably much lower inheritance if their enrolled ancestors continued to marry low inheritance Indians or Whites. Regulations concerning eligibility for contract care services are more restrictive and generally allow only enrolled individuals to obtain contract care through the IHS (certain other requirements regarding residence also apply). There are no socioeconomic indicators on hospital records because free services are available regardless of financial need.

Data from the Indian Health Service show 7,247 individuals visited health care facilities (Cherokee Indian Hospital, Snowbird Clinic, and Swain County Hospital in Bryson City) during fiscal year 1988. Because the IHS facility is used by the vast majority of Cherokees in the area, including those in Graham and Cherokee Counties, its caseload probably provides a valid database for estimating diabetes prevalence in the Eastern Cherokee population.

2. PROCEDURE

The primary methodology used in describing the prevalence and distribution of diabetes mellitus in the Eastern Cherokee was a search of various data sources, including census records, enrollment records, and the Cherokee Indian Hospital Ambulatory Patient Care database. Incidence and prevalence rates were calculated according to standard epidemiological methods (Lilienfeld and Lilienfeld 1980).

Data Sources

Census Records

Data on Indian populations contained in the standard U.S. census for each state include population size and information on social characteristics such as income, education, and employment status. These data are for all Indians in an area and are not broken down by tribal affiliation. Population figures are available for each county in North Carolina, but information on social characteristics is available only for the two counties having the largest Indian populations (Jackson and Swain). Furthermore, data for Haywood County (part of the IHS service area having no reservation land) are not provided in the census because of the relatively small number of Indians living there. This study uses census data for the five-county Indian Health Service Cherokee service area in order to insure that statistics apply primarily to the Eastern Cherokee and not another North Carolina Indian group such as the Lumbees.

A Subject Report from the 1980 Census, American Indians, Eskimos, and Aleuts on Identified Reservations and in the Historic Areas of Oklahoma (Excluding Urban Areas) (U.S. Department of Commerce 1985), provides rather detailed socioeconomic and population data for recognized tribes living on reservations. This census, however, is of somewhat limited value in making general statements about the Eastern Cherokee because many Cherokees live off reservation land, especially in Graham and Cherokee Counties where Indian land exists only in scattered parcels. Although it is difficult to say whether significant income differences exist between on-reservation and off-reservation residents, it is probable that off-reservation residents as a whole have higher incomes. One possible indication that this may be so is the way in which new homes are purchased. If one has a sufficiently low income, one may qualify for Housing and Urban Development subsidized housing available through the tribe's Qualla Housing Authority, all of which is constructed on reservation land. Persons who do not qualify for Qualla Housing usually have to deal with private lenders. Because reservation land cannot be used as collateral for a homebuilding loan, individuals must either be able to finance the entire cost of the house on the reservation, or buy a parcel of land off the reservation to use as collateral. Thus those using private lenders and building on off-reservation land (particularly in the past 20 years) may have higher incomes than those living on reservation land.

Despite limitations of these census data with respect to income, the data are tribe specific. Of particular value are data on the number of Cherokees actually enrolled in the tribe, and those belonging to other tribes, but living on the Cherokee Reservation.

Unless indicated otherwise, data from these two census reports are used to calculate prevalence rates and to provide socioeconomic information for examining the relationship between socioeconomic status and diabetes prevalence.

Enrollment Records

The Baker Roll (Baker 1931), which enumerated all Eastern Cherokee individuals alive at the end of 1924, forms the basis of current tribal enrollment. Nearly half of the diabetics alive at the end of 1988 would have been alive at the time the roll was taken and probably many others' parents were on the roll. Thus the roll provides a good picture of the tribe at that time in terms of population and distribution of inheritance. Unfortunately, families are not listed by residence on this roll and there are no data on socioeconomic status.

In order to assess whether the present enrolled population is significantly older than that described on the Baker Roll, and thus whether the current population may be at greater risk for diabetes, the Baker Roll was computerized so that a population profile might be generated from it.

Cherokee Indian Hospital Patient Care Database

The Indian Health Service Cherokee service unit maintains computerized patient care records that are updated at each patient visit. Currently, a diabetes registry of sorts is maintained by the diabetes nurse and the Diabetes Control Officer who periodically check and update the list of patients generated from the database who have diabetes on their problem lists. This list contains diabetic cases used to calculate prevalence rates for this study. Data, including chart number, date of birth, residence and degree of inheritance were available from this list. Unfortunately, date of diagnosis was available for only about a third of these patients, so incidence statistics cannot be calculated. A new registry system being developed at present will contain much more detailed data for future analysis. For the purposes of this research, a dataset was constructed from the current registry so that statistics could be calculated. Statistical analysis employed Statistical Analysis System (SAS) statistical software for the IBM personal computer.

CHAPTER III

RELATED LITERATURE

Published descriptions of diabetes in American Indian populations began with observations of increased prevalence of the disease in various Indian populations. The fact that diabetes was so common among Native Americans resulted in research in which the percentage of "Indian genes" (defined as degree of Indian inheritance on tribal rolls) was an important variable. Research linking obesity to diabetes led many researchers to document prevalence of obesity in American Indian groups, since many of these populations have become more obese. As in studies of diabetes prevalence, most of these studies also included degree of American Indian inheritance in their studies. Results of this early research showing diabetes to be more common among Native Americans than among the general U.S. White and Black populations naturally led to attempts to find genetic factors in diabetes etiology, particularly some genetic difference between Native Americans and others. Paralleling these developments were clinical studies, particularly among the Gila River Pima of Arizona, which have provided the greatest body of research on diabetes of any American Indian group. Recent discoveries of abnormalities in glucose metabolism in the Pima, and the fact that these abnormalities are familial, coupled with studies showing family history to be a more significant risk factor than age, sex, and obesity, indicate that previous studies need to be reinterpreted in the light of demographics. In American Indian populations, factors leading to population bottlenecks and "founder effect" need to be considered in interpreting previous studies of diabetes epidemiology. Thus, some discussion of ethnohistoric and ethnographic descriptions of the Eastern Cherokee are increasingly relevant to an understanding of the distribution of diabetes in that population today.

Chapter III
Related Literature

This chapter begins with descriptions of some of the epidemiological studies of diabetes and obesity, followed by a discussion of the "thrifty-gene" hypothesis as related to findings from new clinical studies, and concludes with a description of historical and ethnographic factors that may explain the preservation of a diabetes-prone genotype among the Eastern Cherokee.

1. EPIDEMIOLOGICAL STUDIES OF DIABETES IN AMERICAN INDIANS

There has been a steadily growing body of literature on the diabetes epidemiology in Native Americans since the mid 1960s, much of which is reviewed in Weiss et al. (1984a), Sievers and Fisher (1985) and Szathmary (1987). Certain early literature is described here to provide a historical perspective, but the focus of this section is on those studies emphasizing intratribal variability.

In the 1970s physician Kelly West (1974; 1978) undertook an extensive review of medical records of civilian and military physicians serving Oklahoma Indians between 1832 and 1939, as well as various other archival material of the period, concluding that diabetes was probably non-existent prior to 1940. According to West, diabetes appeared to become more common after that time, so that by 1955 rates were not significantly different between Indians and Whites. However, by 1963, government reports showed diabetes-related death rates in persons forty-five to fifty-four years of age to be 59.3 per 100,000 population for Indians and only 12.1 per 100,000 in Whites. Based on this evidence, West suggested that a "massive epidemic" of diabetes is occurring among American Indians that "began in the 1940s in a few tribes, reached substantial proportions of geographic scope and severity in the 1950s, and became massive in the 1960s" (1978:33).

One study cited in the above work by West is by Drevets (1965). From a retrospective chart review of records at the Talihina Indian Hospital in southwest Oklahoma, Drevets estimated diabetes prevalence to be 53.2 per 1,000 "full-blooded" (4/4 degree inheritance) Choctaws and a prevalence of 18.3 per 1,000 "mixed blood" Choctaws. His "mixed-blood" category included only those having 1/2 or more "Indian blood." Unfortunately, Drevets provided no statistical analysis to show association and it is impossible to make such calculations from the published data.

Among these early studies of diabetes prevalence in Native Americans that stimulated the previously mentioned work by West is one undertaken among the Eastern Cherokee in North Carolina described by Stein et al. (1965). In this study, distribution of the disease according to age, sex, and degree of Indian inheritance were determined by means of screening individuals for impaired glucose tolerance, rather than by examining medical records.

Although their original plan called for a random sampling of the Cherokee population, circumstances forced researchers to make use of a volunteer sample of individuals (n=448) from the five communities on the Qualla Boundary portion of the Cherokee reservation. Study participants were all over 34 years of age, representing about 36% of the total number of Indian adults on the tribal rolls at that time. Seventy-seven individuals included in the study identified themselves as Indian but were not listed on the tribal roll. Data on degree of inheritance for each member of the sample were obtained from the roll. Thus the sample consisted of 154 individuals with 4/4 degree inheritance (34.8% of the sample), 105 were classed as 75-99% inheritance (23.7% of the sample), 43 were 25-49% inheritance (9.7% of the sample), and the remaining 30 (6.8% of the sample) were less than 25% Indian inheritance. Study participants were given a glucose tolerance test, with 143 participants being tested after two to eight hours of fasting, the remainder without fasting. Results of the testing showed 130 of the 448 participants

(29%) to have abnormal glucose tolerance indicative of diabetes (150 mg/100 dl or greater), and an additional 49 individuals (10.9%) to have "borderline tolerance" (120 to 149 mg/100 dl).

Prevalence of abnormal or borderline glucose tolerance varied with the degree of Indian inheritance, with 40% of the full inheritance group, 48.57% of the 75-99% inheritance group. 55.81% of the 50-74% group, 23.49% of those in the 25-49% group, and 23.33% of those less than 25% inheritance showing abnormal or borderline glucose tolerance. A X^2 statistic calculated from their published data showed a significant association between blood degree and presence or absence of impaired glucose tolerance (X^2=11.647, df=4, p >.0005). Although the X^2 showed the number of occurrences of abnormal or borderline tolerance is not homogenous across categories, the fact that more cases occurred in the second highest category than in the highest begs for explanation. One explanation may be that the findings are artifacts of categories used to tabulate results. Intuitively, there would seem to be little difference genetically whether or not an individuals are 99% Indian or 100% Indian. However, a similar distribution of diabetes and borderline glucose tolerance occurs when the two categories are collapsed (X^2=16.009, df=3, p >.0005). Another explanation lies in sampling bias, since the sample was not stratified by age and inheritance. With respect to inheritance, 214 of the total 321 individuals whose inheritance was known are in the 75-100% category of inheritance. Only forty-three persons are in the second highest group. If the number of persons in this category had been larger, the proportion of individuals with borderline or normal glucose tolerance may have been larger.

Stein et al. acknowledge that because their sampling techniques were less than perfect, they could not calculate a diabetes prevalence rate with any degree of confidence. Yet they did conclude that among the eastern Cherokee, "prevalence of diabetes is higher than previously reported". However, several erroneous assumptions about characteristics of the Cherokee population which may have resulted in somewhat inflated rates. For one thing, they made assumptions about their sample from the five communities at Qualla Boundary based on information obtained from the entire tribal roll. Thus, the Snowbird section in Graham County, which has been described as having a higher number of full-blood individuals, and the Cherokee County Cherokees, which have been described as having very low degrees of Indian inheritance, are included in the roll but not in the study sample. This in itself would call into question their statement that "...about one-third of the reservation is still full-blooded Cherokee." There is an assumption that findings based on data from the Qualla Reservation describe diabetes prevalence for the whole tribe.

The question remains whether their sample is representative of the 36% of the total Indian population over 34 years of age and is typical of all Eastern Cherokee in the region, especially with regard to blood degree. The contention here is that it was probably not, because published descriptions of tribal characteristics differ with the assumptions of Stein and his colleagues. Harriet Kupferer (1966) for example cites Gulick's (1960) data on blood degrees of school children in which 22.89% were 4/4 blood degree and 48.8% were 3/4 or greater. Data from a sampling of the Cherokee Central High School described in Ballas (1960) shows 14% to be "full-blood", 29% to be "three-fourths blood", 19% "half-blood", 19% "one-fourth blood", and 19% "less than one-fourth blood." The diabetes study sample was made up of 154 persons with full inheritance (42%) and 105 persons with inheritance degrees of 75-99% (28.7%), so that <u>over 70%</u> of their sample was 3/4 or greater inheritance, a much different composition from that of the total tribal enrollment. It should also be noted that data on blood degree based on data from school enrollment include only those children living at Qualla Boundary, because children in Graham and Cherokee Counties attended school there.

Another aspect of the study by Stein et al. (1965) that could lead to a great overestimation of diabetes prevalence are their criteria for defining diabetes. Sievers and Fisher (1985), Szathmary (1987), and others have noted that comparisons of diabetes rates across tribes are made difficult by inconsistent definitions as to what level of serum glucose was indicative of diabetes as well as differences in research methodologies. It is also important to interpret results of these early studies in the context of the times in which they were undertaken:

> ...During the 1960s, enthusiasm for screening and early diagnosis of asymptomatic diabetes on the basis of glucose tolerance tests was mounting. This coincided with an increased use of batteries of laboratory tests due to the introduction of automated laboratory equipment, as well as increases in the utilization of medical facilities throughout the population...(Krolewski and Warram 1985:30).

Current criteria established by the National Diabetes Data Group, which are now commonly accepted as guidelines for defining diabetes include three indicators of diabetes summarized briefly below (a copy of current standards used by the Indian Health Service may be found in Appendix I):

1. Random plasma glucose >= 200 mg/dl plus presence of classic signs and symptoms.
2. Fasting plasma glucose >= 140 mg/dl on at least two occasions.
3. Fasting plasma glucose >140 mg/dl plus sustained plasma glucose levels during at least two oral glucose tolerance tests of 200 mg/dl or greater.

It should be noted that these criteria were developed for the general population and not specifically for Native Americans.

Thus many individuals in the 1965 study found to have "abnormal glucose tolerance" or "borderline tolerance, or even those with diagnosed diabetes, would probably be identified today as having "impaired glucose tolerance" rather than diabetes. Some of these persons may have gone on to develop diabetes, but not necessarily (Bennett et al. 1988).

Chapter III
Related Literature

Based on currently accepted criteria, many of the individuals defined as diabetic by Stein et al. (1965), would not be classified as such because (1) the test was random for nearly 3/4 of the study sample, was only given once, and presence of classic signs and symptoms was not noted, or (2) the fasting plasma glucose levels they note are consistent with diabetes (>150 mg/100 dl or greater) were only obtained on one occasion.

The occurrence of diabetes may have been overestimated in the 1965 research because the sample was not representative of the tribe with respect to blood degree and his diagnostic criteria probably inflates it even further. The methodological problems in the study by Stein et al. (1965), lead one to question its value in comparing data from other tribes. A tribe with either a very low average degree of inheritance, or one including a very large number of individuals with low degrees of inheritance, might be found to have a much lower prevalence of diabetes, ceteris paribus, than one consisting primarily of high inheritance persons. Furthermore, any population changes such as differences in both the mean and proportion of individuals with various blood degrees need to be taken into account when comparing diabetes prevalence rates both within and between Indian populations. Chakraborty and Weiss (1986) have shown that both prevalence of non-insulin dependent diabetes and percentage of American Indian ancestry in the populations studied are significantly associated. In the case of the Cherokee study, however, they include a prevalence rate of .290, whereas Stein never published a rate at all. What they describe as prevalence is the proportion of individuals with previously diagnosed diabetes and abnormal tolerance indicative of diabetes in Stein's sample. As has been discussed previously, Stein's diagnostic criteria are quite different from those used today. In addition, Chakraborty and Weiss (1986) include admixture data based on serological studies conducted in the 1960s (Pollitzer et al. 1962) that may have accurately measured the admixture of that sample, but not that of the diabetes study.

In another study, records of a hospital serving the Three Affiliated Tribes (Mandan, Arikara, and Hidatsa) of North Dakota were reviewed in a study specifically addressing the question of diabetes prevalence in racially heterogenous Indian populations (Brousseau et al. 1979). Despite clinical experiences that led researchers to believe that full-inheritance Indians there "...seem to have fewer clinic visits than mixed inheritance Indians or White people, and therefore are also less communicative about their symptoms," full-inheritance Indians had a disproportionate amount of diabetes (Brousseau 1979:1278). Although Whites were included in the study population described by Brousseau et al., it is possible to calculate a chi-square statistic from their published data in order to determine whether a statistical association existed between blood degree and presence of Type II diabetes. Categories of inheritance include "full inheritance (8/8)," "Less than 8/8 and more than 4/8," and "4/8 or less," although Thornton's (1987) summary of enrollment criteria show enrollment to be limited to persons with 1/4 inheritance or greater. After eliminating data on non-Indians, an association between inheritance and presence or absence of diabetes is found (X^2=27.50, p > .005). Results of their study lead Brousseau, et al. to conclude that "In studying disease prevalence among American Indians, researchers should realize that most tribes are racially heterogenous and that disease rates may vary according to racial admixture" (1979:1278). In a recent follow-up study, Brousseau shows diabetes to be more prevalent than earlier reported, but the pattern of distribution in the population is much the same (Brousseau 1989).

Studies of intratribal variability of diabetes prevalence have relied almost exclusively on legal definitions of inheritance as determined from tribal rolls, which at best only approximate genetic differences. Racial admixture among the eastern Cherokee has been addressed in a study examining the extent of gene exchange between the eastern Cherokee and other ethnic groups (Pollitzer et al. 1962) and a subsequent re-analysis of that data described by Korey (1979). In the original study, blood samples were collected from 706 members of the Eastern Band of Cherokee Indians on the Qualla reservation (about one-quarter of the total reservation population at that time). Only subjects having at least 1/32 inheritance (as determined from the tribal roll) were included in the study. (At the time of the study this was the minimum blood degree requirement for tribal enrollment.) Assuming that gene frequencies found among full-blood subjects were indicative of population frequencies at the time of contact with Whites, an attempt was made to identify which ethnic groups would have combined with the Cherokee to obtain gene frequencies observed in the study sample. Because historical evidence showed that the English and Scotch-Irish predominated among the early White settlers, the hypothesis that most of the "non-Indian" genes came from that group was tested. The hypothesis was tested based on knowledge of the average degree of inheritance in the sample (63%) and published gene frequencies for the English. Using the "gene counting" method, the researchers concluded that "Hybrid Cherokees have been produced primarily by an admixture with an essentially English population." Relatively little admixture with Blacks was observed (Pollitzer et al. 1962:42).

More recently, a re-analysis of Pollitzer's data (Korey 1979) using a method developed by Chakraborty and Nei (1975) which does not assume knowledge of gene frequencies in the aboriginal population indicated the proportion of English or Scotch-Irish inheritance to be somewhat less than that reported in the previous study (.200 compared to .333).

2. RISK FACTOR PREVALENCE IN THE EASTERN CHEROKEE: STUDIES OF OBESITY

The search for causes of the observed high prevalence of diabetes in American Indians has focused largely on the Pima Indians at Gila River Reservation in Arizona who were found to have diabetes prevalence rates 35 times that of Whites in Rochester, Minnesota (Knowler et al. 1978). A long-term study of the Gila River Pima, sponsored by the National Institute of Diabetes, Digestive and Kidney Diseases has provided the greatest amount of consistent long-term data on diabetes of any American Indian tribe. Medical literature concerned with the Pima indicates that diabetes was probably rare prior to the 1950s, yet now affects half the adults over 35 years old. Generally, the high prevalence is attributed to genetic factors described below and socioeconomic changes that led to adoption of a diet high in refined carbohydrates that resulted in increasing obesity (Knowler et al. 1983).

The fact that diabetes was found to be so prevalent in the Pima, who have been described as being very obese, and the fact that obesity has been considered a major risk factor for diabetes in other populations (cf. Krolewski and Warram 1985), led a number of researchers to investigate the prevalence of obesity in various populations in addition to the Pima.

As in other studies of Native American populations, a number of researchers attempted to determine the distribution of obesity with respect to degree of Indian inheritance in addition to other demographic variables such as age and sex. Studies of obesity in the Eastern Cherokee have addressed patterns of obesity in children (Story et al 1986; Tompkins 1980; Driscoll 1982), and the degree of obesity and cultural attitudes regarding obesity in adult women (Terry 1982).

Students at Cherokee High School ages thirteen through seventeen were found to be heavier and have higher values for triceps skinfolds (a measure of fatness) than their Black and White peers included in the Ten-State Nutrition Survey (Tompkins 1980). Although Tompkins found a significant relationship between weight and degree of Indian inheritance, no such relationship was found for triceps skinfolds. Individuals greater than 75% Indian inheritance were found to be tallest and heaviest; however, they were not "fatter" than those with lower percentages of inheritance. Unfortunately, body mass indices were not calculated for these subjects which limits the comparability of Tompkins' findings. However, a later study of the a sample of Cherokee High School students (Story et al. 1986) found a high rate of obesity, but no relationship between triceps skinfold or weight and degree of Indian blood. Driscoll (1982) analyzed data on physical growth of 921 Cherokee Indian children participating in the Special Supplemental Food Program for Women, Infants and Children (WIC). Interestingly, heights and weights of children in the program varied with clinic location with Robbinsville (Snowbird section in Graham County) participants being the tallest and heaviest, Murphy participants being shortest and thinnest, and the Cherokee participants at Qualla Boundary falling somewhere in between. Generally, there was a tendency for children having greater than 75% Indian inheritance to be heavier after two years of age.

In her study of Snowbird women, Terry (1982) found that her data on triceps skinfolds showed that "approximately one-half or greater of the women were classified as obese regardless of the standard used" (ibid. p. 74). Furthermore, mean weight and body mass indices of the Snowbird were higher than any measurements recorded at that time for any other American Indian group except the Pima[1].

The studies by Driscoll (1982) and Tompkins (1980) seem to indicate that there is considerable variability with respect to height and weight among the Eastern Cherokee, and that degree of Indian inheritance is a factor in these differences. Tompkins' sample did not include

[1] Comparisons made to Assiniboine-Gros Ventre, Blackfoot, Navajo, Pima, and Seminole.

individuals from Snowbird, the site of Terry's study, because students from that section of the reservation attend school in Robbinsville. Terry's finding that Snowbird women tended to be obese could be viewed as a continuation of a pattern of that region having heavier and taller children than those from Cherokee or Murphy. Driscoll's finding of variability with respect to clinic site is especially interesting in light of research on the heritability of obesity (see review by Terry 1982).

Terry (1982) emphasizes that Cherokees were probably not heavy in earlier times, so the obesity she observed is probably a recent development. If so, what were the precipitating factors in this change in body size? One factor may be a change in diet, particularly one that occurred prior to World War II, a time in which the roots of the present "epidemic" were in place. Thomas (1958b) describes the period from 1920 to the late 1950s as one of rapid culture change that was accelerated by Government boarding schools. These schools, which emphasized homemaking and craft skills for girls and farming and mechanical skills for boys, have had a significant impact on Cherokee diet and lifestyle. The effect of home economics teaching on girls during this period was assessed by Flanagan (1938) by means of interviews with women who had had no schooling, those who had been to school but had never had any home economics training, and those who had experienced home economics training at the boarding school. Flanagan included only full-blood Indians, or those with very little White blood for her study because "...full-blood Indians are more representative of the Indians on the reservation..." (1938:30). In general, Flanagan found an increase in the variety of foods served to families in the third generation (those who had attended the boarding school and received home economics training). Gathering and using native fruits, greens, and nuts continued into the third generation. However, there was an increasing use of dairy products over the generations, and some rather significant differences in infant feeding practices. In particular, 79% of the first generation weaned children after the age of twelve months, compared to 48% of the third generation. None of the first generation gave children milk, but 73% of the third generation did so.

The number of meals served per day also changed, with 88% of the third generation serving three meals per day compared to 58% the first generation. Four of the thirty-three first generation homemakers served only one meal per day, while none of the third generation did so (ibid. p. 45). Flanagan notes that if two meals were served, there was a late breakfast and an evening meal (ibid. p. 44). She describes typical menus for the first generation as follows:

> The typical daily menus of this generation are, for breakfast: coffee and Indian breads; for dinner: cornbread, beans, corn, or hominy, fat-back pork usually fried, stewed apples or other fruit and coffee; for supper: the menu is much the same as for dinner. There may be a variation of the beans, corn, or hominy. Potatoes are often served in place of one of the latter foods. In summer the native greens are used as well as fresh garden foods and fresh wild foods. The children are allowed to eat the same foods as do adults. There is never a distinction made unless it happens to be the child's desire (ibid. p. 44).

In contrast, menus of the third generation include more foods, and presumably in greater quantities:

> The typical daily menus of this generation are breakfast: coffee, bread, bacon, or eggs, with cereal and fruit occasionally, dinner: cornbread, potatoes, beans, corn, or hominy, with either cabbage, tomatoes, squash, greens, carrots, or peas in season or canned food, with meat of some kind, which is usually pork. Fruit and milk are served in the homes having them. Supper menus are much the same as for dinner.
>
> ...Twenty-one of the thirty-three women indicated that they prepare foods which their mothers did not prepare. These foods include different kinds of desserts, baked products, ways of preparing vegetables, made dishes, salads and yeast breads...
>
> The children eat the same food as served the adults, and in twenty-four of the homes the mothers give their children milk with each meal...While many mothers understand the necessity for certain foods for their children, they do not insist on the children's eating these foods. There is, however, a noticeable change in the attitude of the mothers in this manner and they are discussing better eating habits for children. The children of this generation who are of school age learn in their health classes the need for milk, eggs, and certain fruits and vegetables to help give them strong, healthy bodies (ibid. pp. 56-57).

It would seem, then, that in a population with a genetic predisposition to diabetes, such a dietary change which included more food served more frequently, and a diet containing more refined carbohydrates, would increase the likelihood of such individuals developing diabetes. This dietary shift is clearly documented in Flanagan's study.

At the time of Terry's and Driscoll's research, the Pima studies had merely established that obesity may not be a major risk factor unless there is also genetic susceptibility:

> ...the high diabetes incidence rate in the Pimas cannot be attributed entirely to obesity. For body mass indices between 20 and 25 kg/m^2, which are lower than the means for the U.S. population in most age groups, the age-sex adjusted incidence rate was 10.9 ± 2.9 cases/1000 person-years (rate ± standard error) eight times as high as the 1.34 ± 0.04 cases/1000 person-years (irrespective of obesity) in the predominantly White population of Rochester, Minnesota ...(Knowler et al. 1981:149).

More recent work described below has shown that insulin resistance is familial among even non-diabetic Pimas and that obesity may serve to increase insulin resistance and thus the probability of becoming diabetic.

3. GENETIC SUSCEPTIBILITY TO DIABETES: CLINICAL FINDINGS CONCERNING IMPAIRED GLUCOSE METABOLISM AND A REEXAMINATION OF THE "THRIFTY GENE" HYPOTHESIS"

Findings from the Pima studies now suggest that a predictable series of events is involved in the development of diabetes: genetic susceptibility, insulin resistance, impaired glucose tolerance, and non-insulin dependent diabetes (Bennett et al. 1988). As summarized by Bennett et al. (1988), insulin resistance is indicated by high levels of insulin in the blood in the presence of abnormal glucose tolerance; that is, there is sufficient insulin in the blood, but it is not being used properly. Although other mechanisms may cause this to occur, it has been suggested that peripheral insulin resistance may best explain development of diabetes in the Pima. Comparative studies of Pima and Caucasians show the Pima to have 50% higher insulin levels in a fasting state and 100% higher insulin levels in a post glucose load state than Caucasians for corresponding degrees of glucose tolerance. The observation that abnormalities in glycogen synthesis tended to aggregate in families independently of obesity, age, or sex suggests that this may be the genetic basis for NIDDM:

> Our data provide evidence of a factor(s) that is affecting in vivo insulin action in addition to the effects of age, sex, and obesity (mainly obesity). The actual insulin resistance measured includes both the effects of family and obesity. In other words, simply knowing if an individual is lean or obese is not sufficient to predict his/her degree of insulin resistance. Knowledge is also required of whether he/she is from an insulin-resistant or insulin-sensitive family (Lillioja, et al. 1988:1332).

In light of the above mentioned research, studies of obesity among the Cherokee assess only the extent to which the respective study populations may develop diabetes if they are insulin resistant already and do not assess the distribution of the susceptible genotype. Although no systematic studies of insulin resistance in the eastern Cherokee have been undertaken, IHS clinicians indicate this is the case for nearly all IHS diabetes patients they have encountered (Farrell 1989).

Possible differences in glucose metabolism between Indians and other racial groups imply that those with more "Indian genes," i.e. higher degrees of Indian inheritance, might be more susceptible to diabetes. Indeed, a number of recent epidemiological studies suggest this is true, both among heterogenous Indian populations and among so-called "hybrid populations," i.e. Mexican Americans (Hanis et al. 1986; Stern et al. 1984).

If there is a genetic basis for developing NIDDM as a result of insulin resistance, then questions about origins of the gene or genes for this condition arise, as well as questions as to how such a gene could be maintained in a given population. Evidence for a specific genetic mechanism for developing the disease has been inconclusive (see for example, Knowler et al. 1983; Chakraborty and Weiss 1986; Elston et al. 1974), although James Neel's "thrifty gene" hypothesis is commonly cited as a plausible general explanation for the relatively sudden increase in diabetes (Neel 1962; 1982). As originally formulated, Neel's hypothesis suggested that a "quick insulin trigger" would have been adaptive in populations experiencing "feast or famine" with respect to food supplies. This hypothesis has been criticized on several grounds, e.g. that diabetes confers no selective advantage because it wastes calories, that it confers no evolutionary advantage because it develops after the reproductive years, and that until recently, most people did not survive long enough to develop the disease (Terry 1982:83-84). Additionally, it has been noted that while the hypothesis fits with historical circumstances of the Pima Indians, who lived in a desert environment where somewhat undependable water supplies resulted in intermittent food resources; it is a less plausible explanation for the frequent occurrence of diabetes in groups occupying more provident environments such as the temperate woodlands occupied by the Cherokee (Szathmary 1987:40).

Despite these criticisms, Knowler et al. (1983), primary researchers among the Gila River Pima, continue to accept Neel's hypothesis, based on new physiological evidence:

> ...Pima Indians have resistance to glucose utilization and high insulin concentration in blood, but they appear to have relatively normal sensitivity to insulin actions in fat stores. This could result in increased fat storage when food is available. Thus Neel's 'thrifty genotype' may mediate differences in sensitivity to insulin in various metabolic pathways. In times of alternating feast and famine, these differences in insulin sensitivity may have survival value by increasing fat storage. When food supplies are steady and abundant, as they are for the Pimas today, increased fat storage is detrimental, leading to increased obesity, insulin resistance, and eventually diabetes (Knowler et al. 1983:113).

The conditions under which selection might have favored such a genetic composition may have arisen during early peopling of North America. Support for this explanation lies primarily in the observation that diabetes is less common in Athapaskan and Eskimo peoples than in other Indian groups. An intriguing explanation for this distribution may be found in a recent article by Wendorf (1989).

According to Wendorf, the continuation of a "specialist" economic strategy, suggested by settlements near big game kills, existed for only 600-700 years, and occurred in a circumscribed area:

> ...south of the continental glaciers most Paleoindian hunter-gatherers appear to have followed a "generalist" lifeway with some evidence of sedentary living. Just south of the mountains of Wyoming and extending to southern Arizona and Texas, however, a 'specialist' settlement pattern, with small camps near big game kills in low elevations, additional small camps in high elevations, and an overall highly mobile society, is apparent. For a relatively short period in this bell-shaped region, there are few, if any, large campsites in lower elevations. Instead, low-elevation camps are small and near big game kills. Conversely, the only campsites that are not near big game kills are in higher elevations where mountain and tundra resources were available (Wendorf 1989:514).

Wendorf suggests that those moving east along the ice margin would have found more familiar foods available to them, or at least had time to adapt to new food resources because of staying within the same band of latitude. Those moving south into the area where the "specialist" adaptation continued encountered food resources with which they were unfamiliar and their response was to continue their old ways until they could develop new knowledge of resources and the skills necessary to exploit them. Thus for a time, big game was the most secure resource and campsites tended to occur in lower elevations near big game kill sites. Settlements in higher latitudes, more similar to the tundra environment from which they had come, were centered on exploitation of small game and plant resources more familiar to them.

With respect to the "thrifty gene," Wendorf suggests that the resulting "feast and famine" that may have resulted from reliance on an arctic subsistence pattern based on big game hunting south of the corridor would have been "frequent, but of short duration" because carbohydrates were available in the higher elevations (ibid. p. 516). In addition, he speculates that later arrivals, i.e. Athapaskans

> ...may have entered the 'ice-free' corridor after it had been colonized by plants and animals more typical of the sub-Arctic. 'Thrifty' genes may not have been as advantageous among the Athapaskan populations as they moved south into more typical low-latitude environments. Today, Athapaskan Amerindians do not appear to have the high prevalence of obesity and NIDDM that characterize Paleoindian Americans' (ibid. p. 517).

Wendorf's explanation for origins of the "thrifty gene" present some difficulty interpreting high rates of diabetes among Native Americans in the east if those Amerindians moving east had no use for the "thrifty gene" (cf. Szathmary 1987). Just as Wendorf omits evidence for a high prevalence of diabetes among some eastern Native Americans, he also ignores evidence for a Late Pleistocene environment in the east that may have preserved the "thrifty gene."

There is considerable controversy concerning whether eastern Paleoindians were primarily hunters or foragers. While Wendorf implies an eastern environment more characteristic of the "ice-free corridor," and thus one more familiar to new arrivals, some have suggested this interpretation is oversimplified. For example, Smith (in press) emphasizes the existence of wide open grasslands that would support large herds of grazing fauna and the existence of "...diverse, 'disharmonious' mix of taxa" and suggests that the contrast today between eastern forests and western grasslands was much less during the Pleistocene. That is, "the initial inhabitants of eastern North America would have encountered a difference in degree rather than in kind with respect to open terrain capable of supporting grazing herbivores." He also suggests that extinction of megafauna at the end of the Clovis period (12,000-11,000 BP) required a major shift in subsistence during the Holocene and that "Subsequent Paleoindian groups were left with an increasingly impoverished fauna of diminutive forms, until the modern condition was achieved" (ibid. p. 18). Smith's archaeological work in southern Indiana revealed a number of base camps used for tool manufacturing that appear to have been occupied for prolonged periods. Sites in this area seem to be those of "...highly mobile but territorially restricted (as opposed to 'free-wandering' or 'nomadic') hunter-gatherers with a preferentially hunting-oriented economy. The Wyandotte chert source area may have comprised the core territory of one or more bands" (ibid. p. 57).

Smith concludes that most Paleoindians in the east were predominantly hunters and that the shift to mixed foraging and hunting came later during the Archaic period:

> Meltzer (1984; 1988) suggests that the caribou hunters of the northeastern tundra regions are derived from the generalist foragers of unglaciated eastern North America, representing a case of evolutionary convergence. Other investigators in the Northeast have suggested that the dated Paleoindian sites of the region--Debert, Whipple, Vail, Templeton, and probably Bull Brook, which cluster between 10,600 and 10,400 BP (see Haynes et al. 1984)--represent survivals of the megafaunal hunting pattern as expressed on the Plains. Certainly by 10,000 BP, the Early Archaic exploitative pattern was already established in the Southeast. Simple economy of hypothesis suggests that Paleoindians were predominantly hunter-collectors throughout their range, both temporal and spatial, with variable expressions to allow for regional resource availability...the shift to a foraging adaptation in most of eastern North America probably occurred during the Middle Archaic period (post 8,000 BP) in response to mid-Holocene conditions (ibid. p. 57).

If this interpretation of Paleoindian environment and subsistence is correct, then descendants of these early inhabitants of the eastern United States may well have had and maintained a "thrifty gene" in the way postulated by Wendorf for those in the west.

4. PERSISTENCE OF THE GENE: EXPLANATIONS FROM CHEROKEE HISTORICAL DEMOGRAPHY

If there is indeed a "thrifty gene," and it is part of the genetic makeup of American Indians, what has insured its survival into modern times when it appears to be so maladaptive? One explanation may be in demographic factors, such as population bottlenecks and assortative mating that could have come about because of historical circumstances. Historical evidence suggests this could certainly have been the case with the Eastern Cherokee, descended from a small group of individuals that managed to escape Removal, famine resulting from epidemics and social disruption associated with conflict with White settlers, and isolation of subgroups for various reasons. Some of these processes are described below.

Although Mooney (1900) observed that those 1,000 Cherokees remaining in North Carolina were the "purest-blooded and the most conservative in the nation" (1900:157), a distinct population of "mixed-bloods" remained. In 1851, the Siler Roll enumerated all "Whites" and "Indians" in the eastern Cherokee villages, including a separate listing of 152 persons in the Murphy area (mostly along the Valley River) as mixed bloods (Finger 1984:71). Differences in wealth and education characterized the two groups. Finger notes that Swetland's census of 1869 showed that

> The mixed-bloods owned most of the animals, while many full-blood households had none. Among the full-bloods on Qualla Boundary, Flying Squirrel and Enola possessed the greatest wealth; the former owned thirty-three head of livestock and occupied thirty acres of improved land, and the latter had twenty-three animals and forty acres of improved land. Their wealth was inconsequential, however, compared with that of certain mixed-bloods and Cherokees by marriage living along the Valley River...(p. 128).

The census also showed that less than one-half of the North Carolina Cherokees could read and write their own language, yet the mixed-blood group were literate in English, Cherokee, or both.

To some extent wealth distinctions were a result of the type of environments the two groups occupied. Those persons living along the Valley River occupied a broad fertile river valley that is still farmed today on a much larger scale. Those persons living eastward in the mountainous areas were confined to farming small plots along creek beds where mountain soils are much less fertile, and where present-day farming is limited to occasional small vegetable gardens.

Removal again became an issue after the Civil War, and again the Cherokees became divided over it, although over 200 Cherokees (mostly mixed bloods) had moved west between 1848 and 1869 (Finger 1984:112). The Quallatown full-bloods, represented primarily by Lloyd Welch and Flying Squirrel, opposed removal, while a rival faction composed primarily of mixed-bloods lead by John Ross and James Taylor supported it. In 1880, Ross and Taylor and their followers (some 161 persons) did move to Oklahoma (ibid. p. 140), but as before, some mixed bloods remained in North Carolina. By the end of 1880, then, most Cherokees had moved to Qualla Boundary or to the Cherokee Nation, except for a few groups in Graham County (e.g.Snowbird) (ibid. p. 140), or further west in Cherokee County. Thus historical circumstances continued to alter both the size and composition of the Eastern Band after the initial removal in the 1830s.

The character of the present population has been derived from an initial "founder" population established just prior to Removal, and from a series of movements onto the reservation that continued into the 20th century. In 1819, two small "reservations" of 640 acres were set aside for Yonagunski at Kituhwa between present-day Bryson City and Ela, and for Big Bear near the present site of Painttown on the Qualla Boundary. The Kituhwa group joined Big Bear's settlement some time later. Other towns, i.e. Stekoa and Alarka, and Briar Town continued to exist on the edge of the Nation (Thomas 1958b:9-10). During the 1840s, families moved up from Georgia to Qualla and several Briar Town families moved there as well. People at Cheowa (now Snowbird, near Robbinsville) tended to stay where they were. From the 1880s through the 1920s, a number of families in east Tennessee moved to Qualla, as well as families from Alabama, north Georgia, and a number from the Murphy area. Several families moved onto the reservation from the Judson-Allman area just west of Qualla Boundary during the first two decades of the twentieth century (ibid. p. 20-21).

American Indian populations provide a unique mechanism by which to measure assortative mating -- degrees of American Indian inheritance -- ascertainment of which is prerequisite for enrollment in the various tribes. Generally, the degree of American Indian inheritance is expressed as a fraction such as full, one-half, one fourth, and so forth. Inheritance of offspring is obtained from the sum of one-half of each parent's inheritance. Thus a couple who are each 1/4 Indian inheritance would have offspring that would be 1/4 (1/8 + 1/8 = 1/4); a couple having one partner of one-half Indian inheritance and one partner of full inheritance would have offspring of three-quarters (1/4 + 1/2 = 3/4), and so on. Tribes commonly put a lower limit on the inheritance of individuals eligible for enrollment. For example, current regulations require individuals to be at least one-sixteenth Cherokee to enroll in the Eastern Band (Eastern Band of Cherokee Indians 1982). Sociologist Russell Thornton has reviewed enrollment requirements for all 305 federally recognized tribes and notes that only 53 (17.37%) have no minimum degree of inheritance for enrollment. Most of these tribes are located in Oklahoma, a state in which only one reservation (Osage) is located. Most tribes require enrollees to be at least 1/4 Indian or more, and the Eastern Cherokee are one of only eight tribes in the United States having inheritance criteria, that accept blood degree as low as 1/16. Within the southeastern U.S., Thornton's data show the Florida Seminole and Mississippi

Choctaw to have inheritance requirements of 1/4 and the Florida Miccosukee to require 1/2 Indian Inheritance (Thornton 1987). Degree of inheritance is usually included on records for services for which tribal enrollment or other proof of Indian identity is required, such as eligibility for health services or other tribal benefits.

A now well-known study of the distribution of skin color among the Japanese by Frederick Hulse (1967) illustrates how assortative mating can result in a change in the distribution of alleles in a population. Skin color is a biological characteristic having a genetic basis and is easily measured with a reflectance spectrometer. If there were assortative mating, according to Hulse, skin color would segregate according to social class, because the Japanese upper classes put great value on White skin. In order to test this hypothesis, Hulse measured skin reflectance of groups of school children in various regions of Japan. From family information obtained from his subjects and readings from the reflectance spectrometer, Hulse's findings did suggest that the skin color varied with social class, the higher class having the lightest skin color regardless of region of inhabitance. According to Hulse, the Japanese value on light skin served as a standard of physical attractiveness and social selection resulted in a concentration of light-skinned individuals in the upper class. Perhaps most importantly, however, this social selection process serves to "...enhance the genetic distinctions between subgroups of the population. The outspoken admiration of the Japanese for pale skin has been effective in those social strata whose members had a wider--though not a freer--choice of marriage partners..." (p. 154)As concerns the Eastern Cherokee, if assortative mating according to blood degree were found to exist, then it is possible that the thrifty genotype associated with a high proportion of "Indian genes" would continue to be maintained in the full-blood population, and would be much less common among those more racially mixed. This would in turn be reflected in the distribution of insulin resistance, impaired glucose tolerance, and the potential for developing diabetes in the population.

The distinction between full-blood and mixed-blood has been a continuing theme in eastern Cherokee society, even though many mixed-blood individuals left North Carolina for Oklahoma. For the most part, historians and ethnographers have continued to concentrate on these distinctions primarily in a social sense. That is, they have described categories of individuals within Cherokee society primarily on their socially ascribed degree of Indian inheritance (e.g. "Full-blood" or "White Indian"). The ways in which these categories relate to degrees of inheritance as recorded on tribal rolls is questionable, according to these sources. Furthermore, researchers differ in the ways they equate their social categories to actual inheritance. The fact that historical and ethnographic studies continue to emphasize the importance of these social divisions seems to suggest that there are rather significant cultural factors operating to perpetuate them.

One ethnographer, Robert Thomas (1958a), offers some particularly interesting observations concerning these differences among the eastern Cherokee, and processes that have contributed to their persistence. He notes there are clearly divisions of conservative and non-conservative among the Eastern Cherokee, and that communities tend to be characterized as one or the other based on the number of each division present in the community (ibid. p. 10). Thomas notes that most descendants of mixed marriages prior to Removal were relatively conservative, tending to adopt Cherokee values, rather than those of White culture. These individuals were integrated into the tribe, a process made easier by the fact that most marriages involved White men and Indian women, and Cherokee society was matrilineal. Thus these individuals formed a conservative, but racially mixed group. According to Thomas, the situation today is quite different, in that those who are primarily of Indian ancestry tend to be conservative and people having more White ancestry tend to be more fully acculturated. According to Thomas:

> ...in most of the Cherokee communities, we find a great many of people of 3/4 or more degree of Indian blood and a substantial minority of people under 1/4 degree of Indian blood. There are very few people who tend to be around 1/2 degree of Indian blood. This split between those people of predominantly Indian ancestry who preserve much of Cherokee culture and those of a small degree of Indian blood who are very acculturated seems most pronounced at Big Cove ... and at Bird Town (ibid. p. 10).

The change in the relationship between acculturation and blood degree may be explained by several factors, as suggested by Thomas. First of all, many of the "White Indians" on the reservation today are descended from families that intermarried with Whites and remained separate from the North Carolina Cherokee after Removal, moving onto the reservation during the 1890s. Thomas notes that these families have always been looked upon as intruders by other Cherokee, and the group has maintained itself by obtaining mates from elsewhere. In Thomas's words, "They lived on the reservation, but were never part of it" (ibid. p. 16). Another group of individuals who were of mixed ancestry, but who had moved onto the reservation much earlier, also existed, but prejudice against this group did not appear until after World War I when the Cherokees began to associate intermarriage with Whites with the decline and death of Cherokee culture. According to Thomas, "...Cultural symbols are no longer of concern to the generalized Indian, so "race" or physical type (symbolizing little Indian blood and, thus not a part of the community) has become the symbol of Indianness" (ibid. p. 26). Thomas predicted that Cherokee society would be composed primarily of "generalized Indians" who consider themselves Indian, more in the sense of belonging to a minority group, in much the same way as members of other such groups (ibid. p. 23).

At the time of his work (late 1950s) Thomas noted the tendency for younger White Indians to marry back into the community or to leave the area, and that "...those White Indians who wish to remain in the community are choosing Indian mates, and those who are not so tied to the community are leaving the area...the community is split, in the eyes of the Cherokee, into Indians and White Indians" (ibid. p. 27).

Assortative mating based on biological characteristics, e.g. blood degree, skin color, body type, or even non-biological ones such as geographic distance between townships would be a logical explanation for the continuing distinction between full-blood and mixed-blood in Cherokee society.

The effects of assortative mating would be magnified in a population that had experienced a significant bottleneck as the Cherokee experienced with Removal because it further reduces genetic variability in the population (cf. Roberts 1968). The possibility of further amplification of this effect due to other factors such as anthropometric characteristics, or cultural variables (cf. Susanne and LePage 1988; Buss 1985), should also be considered.

CHAPTER IV

RESULTS

1. DIABETES PREVALENCE

A list of individuals currently diagnosed as having diabetes was obtained from the Indian Health Service patient care database along with each individual's sex, degree of Indian inheritance, and community of residence. The age range of diabetic patients was quite broad, from 12 to 100 years, the mean being 55.10 (SD=14.087). Table IV shows the distribution of patients' ages by age categories used by the tribal health office in calculating service usage statistics. Of the total of 603 adult-onset diabetics identified, 369 were females and 234 males, a sex ratio of 1.58 females for every male. A preponderance of females in the diabetic patient population occurred in every age decade, with the smallest ratio occurring in the 40 to 50 year age group (1.02) and the highest in the under 20 group (3.0). These data are presented graphically in Figure 4. From these data it can be seen that diabetes is much more prevalent among women than among men - at least 1.3 times greater. The percentage of each age group that is diabetic is depicted graphically in Figure 5.

Because previous research findings show a tendency for diabetes to occur more commonly in full-blood Indians than in mixed-blood individuals, the number of individuals for each category of inheritance degree (in quartiles) on the current rolls was obtained (IHS 1988). Prevalence rates for each quartile of inheritance degree were calculated from these data.

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Table IV Age Distribution of Cherokee Diabetic Patients (Type II Only)

Age Category	Number of Cases	Percent of Cases
10 - 14	1	.17
15 - 19	2	.33
20 - 24	9	1.49
25 - 44	156	25.87
45 - 64	270	44.78
Over 65	165	27.36
	603	100.00

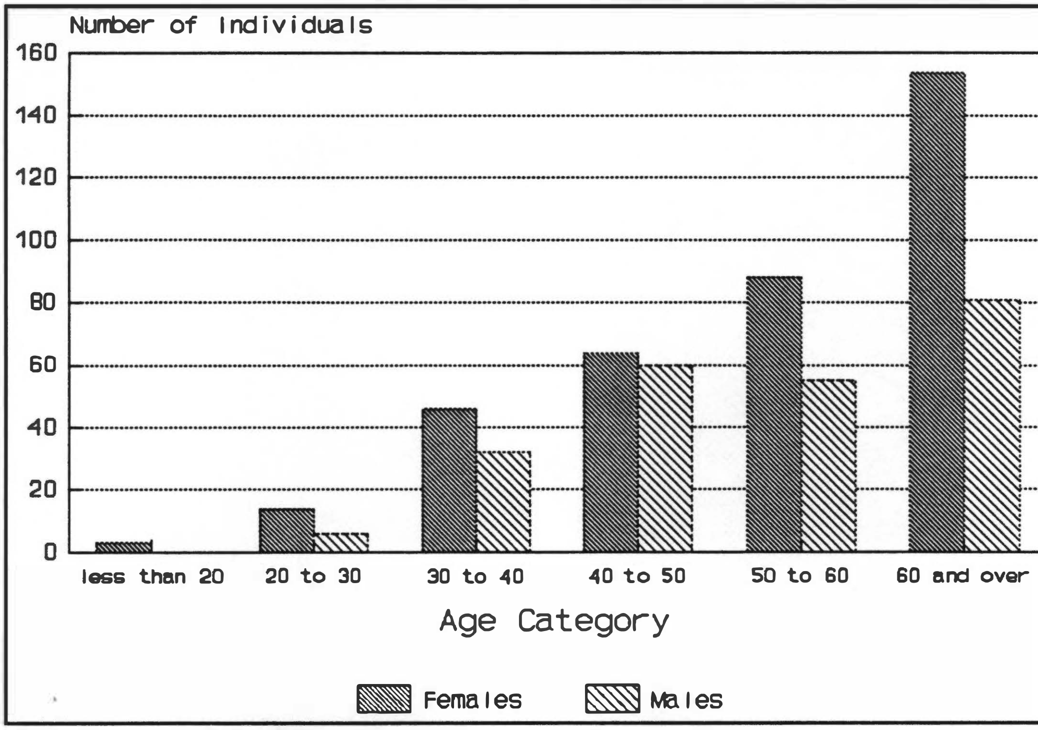

Figure 4 Age and Sex Distribution of Diabetes Patients

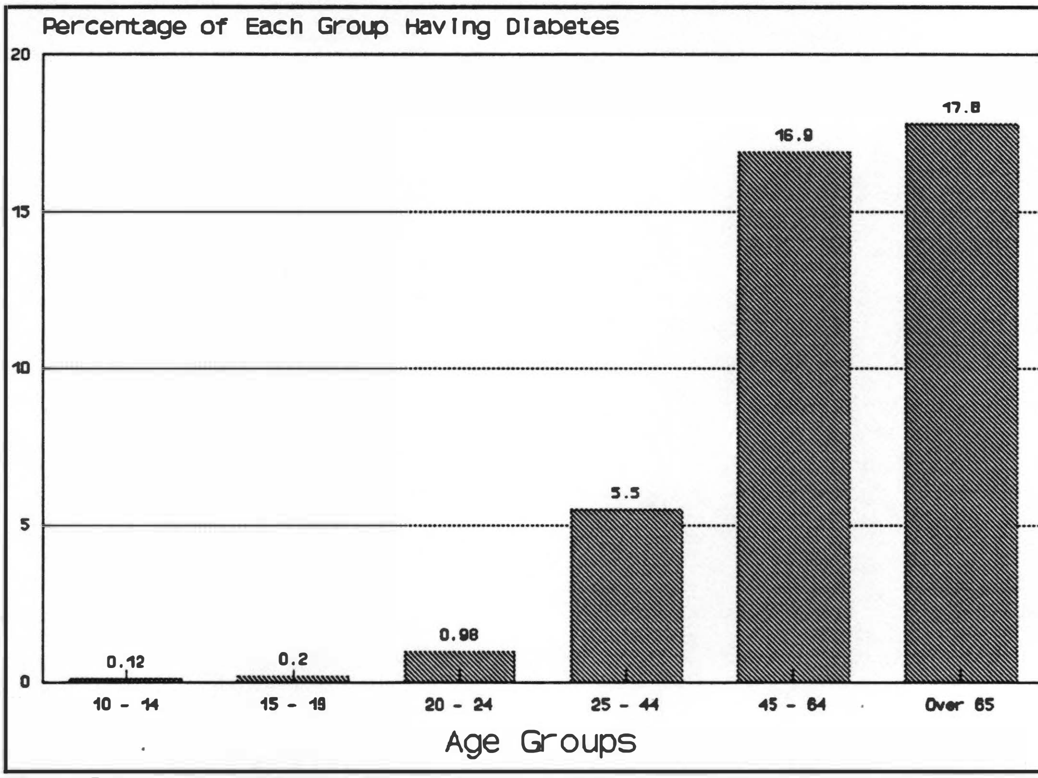

Figure 5 Percentage of Persons Having Diabetes: Selected Age Groups

number of individuals at that time (the end of 1987) was 9,370 and included individuals ranging from 1/128 to 4/4 blood degree, with the mean being or just under 1/2 (.442). Average blood degree of diabetics was .75 (SD=.3091) and ranged from .0039 to 1.00. Prevalence of diabetes within each inheritance category is shown in Table V. The distribution of diabetes within the selected age groups shows that more than one of every six Eastern Cherokee 45 years of age or older has diabetes. About one in six persons whose degree of Indian inheritance is at least 75% has diabetes, but only one in sixteen persons with inheritance of 50% to 75% has diabetes. In other words, persons greater than 75% inheritance are 2.5 times more likely to be diabetic than those in the next lowest inheritance quartile.

Over 60% of the diabetics were greater than three-fourths Indian inheritance, while just under 25% of the tribe as a whole have inheritance degrees over three-fourths. Among the diabetics, a negative correlation between degree of inheritance and age was found (r=-.158), so that younger diabetics had higher degrees of Indian inheritance. Differences in inheritance degree between the diabetic patient population and that of the tribe as a whole are shown in Figure 6. (No statistics are calculated because data for each group are from different years).

Information on the geographic distribution of patients was obtained from residence data provided for each patient in the database. A map showing locations of these towns is in Appendix II . Table VI shows the number of patients from each location. Although seven persons came from other states, 80% live on the Qualla Boundary portion of the reservation, or on the neighboring 3200 Acre, or Thomas, Tract. Others (24) live in Cherokee County, near Murphy which is 57 miles west of Cherokee and the Indian Health Service Facility. Another 55 persons live in the Snowbird area of Graham County near Robbinsville which is located about forty miles west of Cherokee. Twenty patients live between Cherokee and Graham County in Bryson City (the county seat of Swain County) or in nearby

Table V Diabetes Prevalence in Each Quartile of Inheritance Degree

Inheri-tance (%)	Number of Cases	Number in Population	Prevalence (per 1,000)
> 25	62	3,354	18.5
25 - 49	78	2,302	33.8
50 - 74	90	1,459	61.7
75 or more	373	2,255	165.41
	606	9,370	64.35

Table VI Geographic Distribution of Diabetes Cases, Eastern Cherokee, 1988

Town Or Community	Number of Cases	Percent
Andrews	10	1.65
Asheville	4	.66
*Big Cove	71	11.78
*Big Witch	5	.83
*Big Y	46	7.59
*Birdtown	74	12.27
Bryson City	10	1.65
Canton	1	.17
*Cherokee	110	18.15
Culberson	1	.17
Marble	5	.83
Murphy	7	1.16
*Painttown	59	9.78
Snowbird/Robbinsville	56	9.29
*Soco	116	19.24
Sylva	2	.33
Topton	1	.17
Whittier	10	1.65
Unknown N.C.	6	.99
Other State	7	1.01
Unknown	2	.33
TOTAL	603	100.00

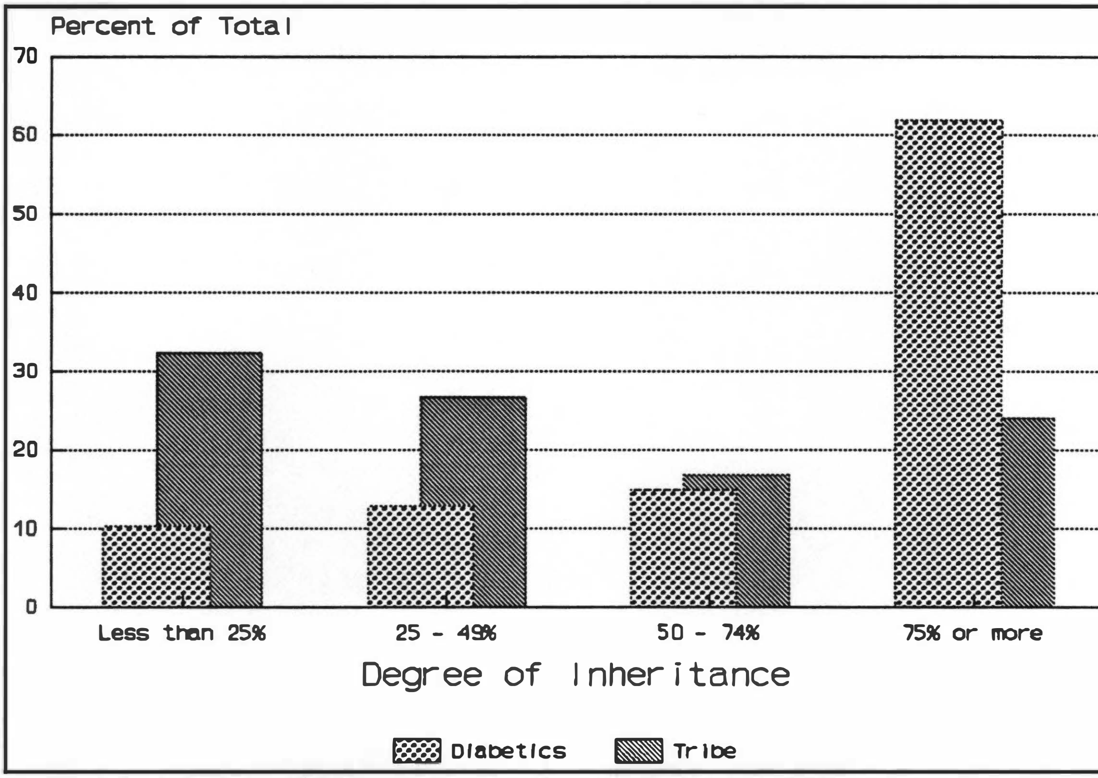

Figure 6 Distribution of Inheritance Degree: Diabetic Patients and Tribe

Whittier. Fifteen persons live east of Cherokee, ten of whom live in Asheville, which is forty-eight miles from Cherokee and is the largest city near the reservation. Three persons live in Sylva, the county seat of Jackson County, and one person lives in Canton, about thirty miles east of Cherokee and twelve miles west of Asheville.

It is possible to calculate crude point prevalence rates for each reservation community from population figures compiled by the tribal health office. These figures are based on voting lists for tribal elections and include all residents of these communities, regardless of whether they live on or off reservation land. Percentages of individuals living off reservation land vary from only 11% at Snowbird to 81% in Cherokee County, but most communities have about one-quarter of their residents living off reservation land. To some extent this is due to the fragmented nature of reservation holdings, even at Qualla Boundary. However, many Cherokees live in neighboring communities by choice. Because Indian Health Service records do not specify whether an individual does or does not live on reservation land, all community residents were considered in calculating crude prevalence. It is possible to calculate diabetes rates for reservation communities because population data are available for each community. As can be seen from Table VII, there are considerable differences in prevalence rates between the various communities, with rates ranging from a low of 34.29 per 1,000 in Tomotla to 85.19 per 1,000 in Snowbird. In Snowbird, one of twelve persons has diabetes, while in Tomotla only one in thirty has the disease. Thus, residence of Snowbird are 2.5 times more likely to have diabetes than residents of Tomotla.

As noted previously, prevalence data included in this table were based on population data from the tribal health service. An alternative method, based on census data, could also have been used. However, census data may not be an appropriate denominator in the case of a racially heterogenous population such as the Eastern Cherokee, because the census relies on

Table VII Crude Point Prevalence of Diabetes in Each Reservation Community, Eastern Cherokee 1988

Community	Number of Cases	1987 Population	Prevalence (per 1,000)
Snowbird	46	540	85.19
*Wolftown	167	2,094	79.75
Yellowhill	109	1,360	80.15
Big Cove	70	1,174	59.63
Painttown	58	1,151	50.39
**Tomotla	23	700	34.29
Birdtown	73	2,166	59.44
TOTAL	549	9,185	59.44

* Includes Soco, Bigwitch, and Big Y
** Includes Andrews, Marble, Murphy, Culberson, and Topton

Population data from 1987 Tribal Health Report self-report of race and ethnicity. Whether or not individuals identify themselves as Indian may depend on circumstances. This is especially true in the case of Cherokee County where there is an increasing tendency to identify as Indian (c.f. Neely 1976), particularly since they have become eligible for tribal health services. It seems probable that ethnic identity is a factor in the discrepancy between the 1980 U.S. Census, which lists only 196 Indians in Cherokee county, and the tribal voting list, which names 700. A large discrepancy is also found in the number of persons living on tribal land, the tribe listing 130 individuals and census data show only 76. If diabetes prevalence were calculated from census data, crude prevalence would be 117.35 per 1,000 compared to a more realistic 32.86 per 1,000 calculated from tribal population figures. Table VIII shows prevalence figures calculated by both methods for each county.

Although the discrepancy in prevalence rates calculated from census data is greatest in the case of Cherokee County, the data are also distorted to a considerable degree for the other counties. Thus, the Swain County rate calculated from census data is nearly twice that calculated from tribal data as are other rates. Use of census data should probably be limited to situations in which comparison to other groups is necessary. This presumes, of course, that all others are underestimated to the same extent. For health planning purposes, it would probably be more accurate to use numbers based on tribal enrollment, or even better, on user-populations of facilities.

It has been noted that diets of Whites and Indians in this area have similar diets (Terry 1982; Terry and Bass 1984). Because income appears to be inversely related to diabetes prevalence, it seems worthwhile to compare intraregional differences in income to see if there are differences between Whites and Indians. If the difference is large, one may suspect that socioeconomic differences may account for some of the rather large differences in the diabetes mortality rates.

Table VIII Prevalence of Diabetes, by County: Results of Calculations Based on U.S. Census to Those Based on Tribal Enrollment

County	Population: Tribe	Population: Census	Number of Cases	Prevalence (per 1,000) Based on Census	Prevalence (per 1,000) Based on Tribal Pop.
Graham	540	360	46	127.78	85.18
Jackson	3,245	1,911	225	117.74	69.34
Swain	4,700	2,423	252	101.08	53.62
Cherokee	700	196	23	117.35	32.86
TOTAL	9,185	4,960	546	110.08	59.44

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The Eastern Cherokee have been described in the literature as showing great variation with respect to wealth from pre-Removal into the 20th century. Census data from 1980 (reservation residents) show median income per household to be $8,993, the mean being $10,421. (Median income is a better measure of central tendency than the average because it is less sensitive to extreme values.) The average income per person over 15 years old was $5,155, with the median being $4,235. Census data that include all economic characteristics of all Indians in a given county are only available for Jackson and Swain counties and show the median incomes to be $9,832 and $9,874, respectively. Median incomes of Indians and Whites do not differ greatly in Swain County ($9,880 for Whites and $9,874 for Indians), but do in Jackson County ($11,649 for Whites and $9,832 for Indians). Percentages of Indian and non-Indian families having incomes below poverty described in Chapter 2 show that within the state of North Carolina, there is a great difference between Indians and Whites, but not between Indians and Blacks. However, county-specific data (shown in Chapter 2) show differences between Indians and Whites are not that great.

In the United States, diabetes prevalence has been shown to be inversely related to income, and thus to be more prevalent among the poor. Table IX below is taken from the 1985 National Health Interview Survey and clearly shows this trend. Also included in the table is the percentage of reservation Cherokee with incomes in these categories.

As the table shows, over 50% of Cherokee Reservation families are within the lowest income category having the highest prevalence of diabetes and 89% fall within the two lowest categories.

Within the Cherokee reservation area, diabetes prevalence and the percentage of reservation Indian households having incomes below poverty appear to be related

Table IX U.S. Prevalence of Diabetes, By Age and Income: Comparison to Cherokee Rates

Family Income $	Prevalence of Diabetes (per 1,000) Less Than 45 Years	45-64 Years	65 Yrs. or more	% Cherokee Families
Less than 10,000	7.1	82.4	117.2	51.19
10,000 - 19-000	6.2	71.7	110.4	37.80
20,000 - 34,999	6.8	45.5	101.8	9.11
Over 35,000	4.1	28.9	84.9	1.74

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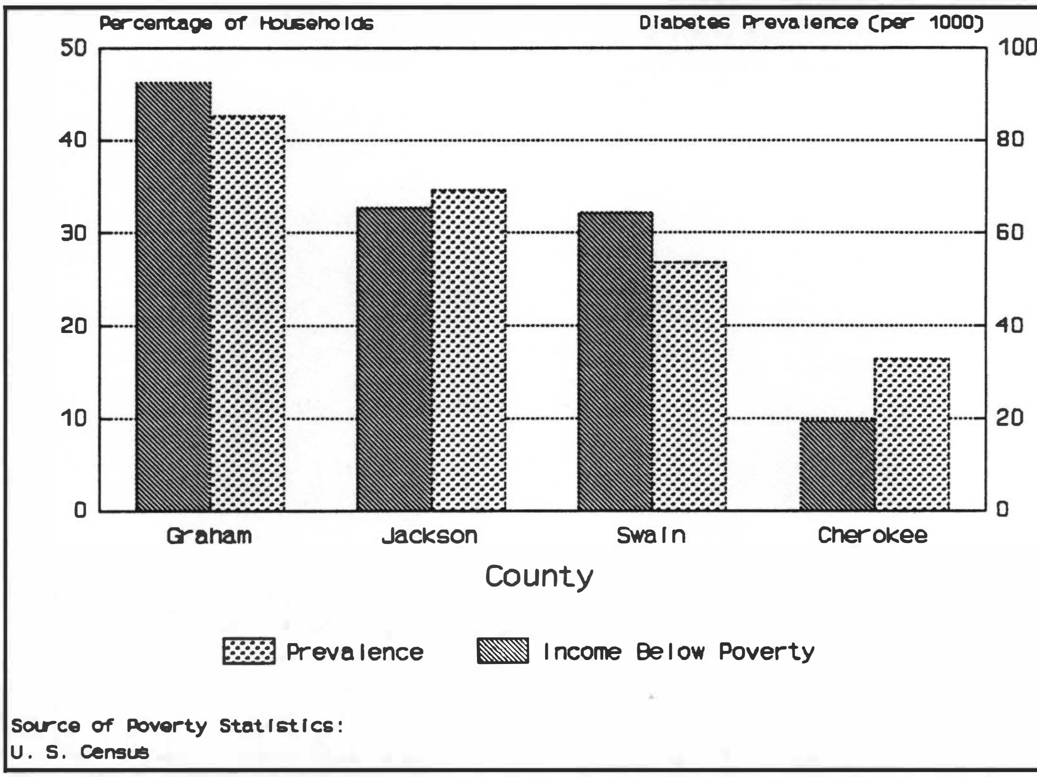

Figure 7 Percentage of Reservation Families Below Poverty Level and Prevalence of Diabetes, Each County Containing Reservation Land

Source of Poverty Statistics: 1980 Census of American Indians, Eskimos, and Aleuts on Identified Reservations and in the Historic Areas of Oklahoma (Excluding Urbanized Areas

2. POPULATION CHANGES

A microfilm copy of the 1924 Baker Roll was obtained from the National Archives Branch. The roll was photocopied and computerized by the author in order to determine distributions of age and degrees of inheritance.

Changes in Age Distribution of Population

The finalized Baker Roll included 3,157 individuals of whom 1,499 (47.5%) were females and 1,658 (52.5%) males. Ages of enrollees ranged from 6 months to 100 years, with the mean being 24.37 years (SD=18.86). The age distribution was skewed toward the lower end so that the median age was 18.5 years and the modal age 5 years.

Changes in Average Degree of Indian Inheritance

Degrees of inheritance ranged from 0.0078125 (1/128) to 1.0 (4/4), the mean being .479 ± .426. Distribution of these data was bimodal with those one quarter or less inheritance making up 46% of enrollees and those of three quarters to full inheritance making up 41%.

The Cherokee population today is generally older than the Baker Roll population. In addition there is a higher average degree of inheritance, and the bimodal distribution is less apparent (see Figure 8). Figure 9 shows that a greater proportion of the population is over the age of forty-four years today, whereas a greater proportion of individuals were less than forty-four on the Baker Roll of 1924.

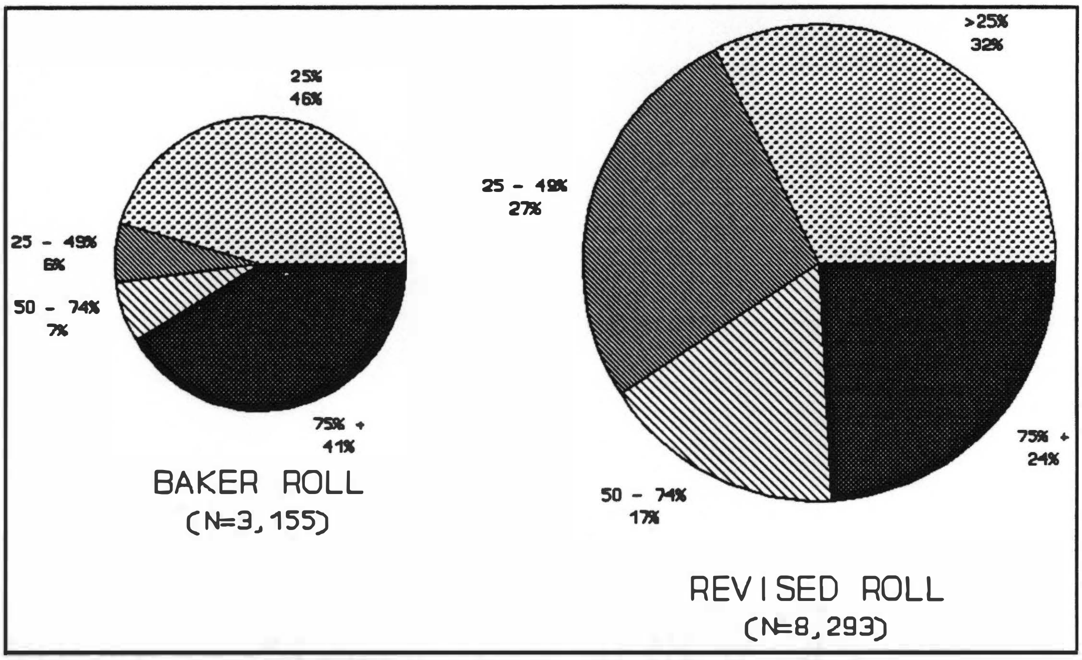

Figure 8 Comparison of Distribution of Indian Inheritance on Baker Roll and Currently Enrolled Descendants of Baker Enrollees

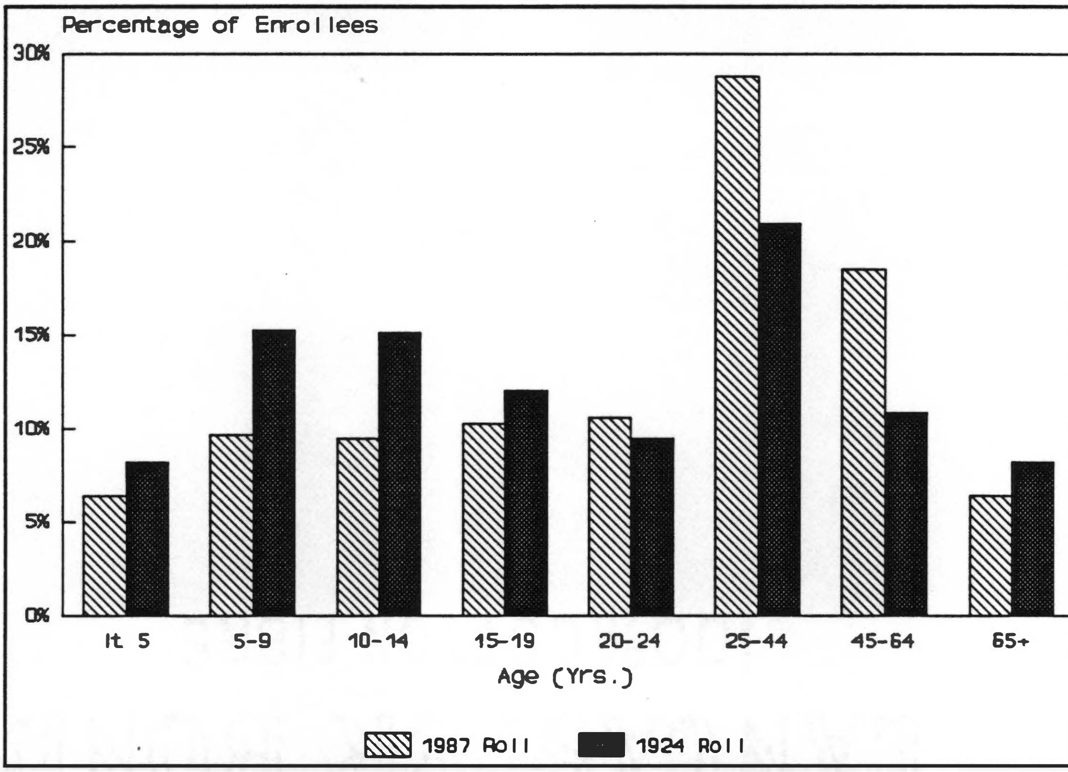

Figure 9 Comparison of Age Distributions of Baker Roll and 1987 Enrollment

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The most logical explanation for the striking bimodal distribution of inheritance in the Eastern Cherokee is assortative mating based on degrees of inheritance. In order to test this hypothesis, a subset of "mated pairs" was extracted from the Baker Roll. Some 546 pairs were identified along with their inheritance (except for three individuals). Pairs were extracted if 1) a household head and wife were included in the same grouping, or 2) if a household head or wife were listed and the spouse identified as non-Indian (usually White) in the "remarks" column. A total of 242 (46.6%) of the mated pairs included a non-Indian spouse. It is probable that there were more non-Indian spouses than were identified because the children of a household head or wife in some cases were assigned half the inheritance of the enrolled parent. However, only those individuals with a spouse actually mentioned on the roll were included in the data subset. Mean inheritance for both males and females was slightly higher for the data subset than for the total roll in that the mean for males was .534 (SD=.446) and for females .503 (SD=.444).

Degree of inheritance for both males and females in the pairs was skewed in the same way as the total roll. For males, this meant that those less than one quarter inheritance accounted for 39.7% and those of three quarters to full inheritance accounted for 49% of the total. Females were a little more balanced, with 44.6% being less than one quarter and 45.6% being three quarters to full inheritance. This skewing of the data made use of parametric statistics to test for correlations between blood degrees of males and blood degrees of females inappropriate. Accordingly, a non-parametric method (X^2) was applied. Because of low numbers of individuals in the mid-ranges of inheritance categories of "less than 1/2" and "1/2 or more" used in crosstabulating inheritance of males with inheritance of females. A chi-square of 322.313 (df=1) with a probability of 0.0000 was computed, meaning that degree of inheritance of males was not independent of inheritance of females. The relationship was moderately strong (phi=.770). These data are presented in Table X.

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In order to further examine the correlation between inheritance of males and inheritance of females in the sample, a correlation coefficient was calculated. A positive correlation was found (r_s=.652) that was significant at the .05 level. Possible age or generational differences were examined by subdividing the data subset into two groups, one in which the males were less than forty years old, and the other in which the males were forty years old or more. Only seven (11.2%) of marriages of older males with White women involved full-inheritance men and there were no marriages of Indian women married to White men. In the younger group, only three (6.12%) of the marriages involved full-blood Indians married to White females. There were three marriages (2.29% of the total marriages) of full-inheritance females to White men. Marriages of full inheritance males or females to non-Indians were relatively rare, but more full inheritance men were married to non-Indian women (9.01% of marriages to non-Indians) than vice versa (2.29% to non-Indians by full inheritance women). Marriages to Whites appeared to be less common among males less than 40 years old. In general, marriages of non-Indians were to low inheritance Indians. That is, 90% of all marriages involving non-Indian males were to Indian females of 25% or less inheritance, and ninety-two of all marriages involving non-Indian females were to Indian males of three-quarters or less inheritance. The percentage of White females married to low-inheritance men dropped to 79% when the men were over 40 years old. These data tend to show that the well-documented split between "full-blood" and "mixed-blood" continued well into the twentieth century and was perpetuated by assortative mating based on blood degree. One result of this fissioning was further restriction of the gene pool, a process that began just prior to Removal. Thus, new "founders" of these two groups would determine the future genetic makeup of the new groups, and the likelihood certain heritable diseases would occur, e.g. diabetes. The fact that the present population has a higher degree of inheritance on average may, in fact, be due to a change in enrollment criteria from a 1/32 minimum for individuals born before 1957 to 1/16 for those born after that time. In fact, census records show that about 65% of the current reservation population would have had to meet the new criteria.

Table X Inheritance Degree of Males Compared to Inheritance Degree of Females Listed as Husband and Wife on the Baker Roll

	Female		
Male	≤ 50%	>50%	Total
≤50%	225	20	245
>50%	43	255	298
	268	275	543

CHAPTER V

DISCUSSION

1. DISTRIBUTION OF DIABETES IN THE EASTERN CHEROKEE POPULATION

Age and Admixture

Diabetes in the Eastern Cherokee population is concentrated in individuals of greater than 75% Indian inheritance and in those ages 45 to 64. Over 1/3 of the persons having diabetes were at least 60 years old and were of at least 75% Indian inheritance. This distribution is consistent with findings with respect to age and blood degree in other American Indian groups (e.g. Brousseau 1979; 1989; Drevets 1965; Carter et al. 1989). Geographic distribution of the disease shows a high prevalence in Snowbird, a community that is reputed to have the highest number of full-blood individuals, and the lowest prevalence is found in communities said to have a lower number of full-blood residents. Comparisons of Cherokee diabetes prevalence data to those for other tribes for whom blood degree data are available seems to follow findings from Chakraborty and Weiss (1986), that there is "...strong correspondence in NIDDM prevalence with the extent of Amerindian ancestry" (ibid. p. 497). Chakraborty and Weiss include data from Seminoles in Oklahoma and Florida and the Pima, as well as the North Carolina Cherokee, with the latter having the lowest diabetes prevalence and lowest percentage of Amerindian ancestry.

A recently published study by Carter et al. (1989) showed variation in diabetes prevalence among Rio Grande pueblos, but much greater differences between rates in these pueblos and those of neighboring Athapaskan tribes (Jicarilla and Mescalero Apache and Navajo Alamo).

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The percentage of individuals 35 years of age and older having diabetes was approximately that described here for the Cherokee.

Indian Health Service data on diabetes prevalence in the Talequah Service Area (Clark 1989) in eastern Oklahoma, the area serving the Creek and Cherokee Nations, show diabetes prevalence there to be much lower than among the Eastern Band (4.8% of the total user population in Tahlequah compared to 8.4% of the user population of the Eastern Band). It is difficult to say what factor or factors may account for this difference, but three rather obvious possibilities exist, i.e. differences in population age structure, socioeconomic status, and blood quantum distribution.

Data from the 1980 Census of Population's subject report on American Indians, Eskimos and Aleuts provides shows the median age of the Cherokee Nation in Oklahoma to be 24.2 years, compared to 22.6 for the Eastern Band. The proportion of each population aged 25 to 64 years, the group with the highest risk of developing Type II diabetes, is nearly equal (38.6% in the Cherokee Nation compared to 39% in the Eastern Band) (U.S. Department of Commerce p. 33 and 103). Median household income among the Oklahoma Cherokee is somewhat higher than that in North Carolina ($10,034 in Oklahoma compared to $8,993 in North Carolina). Census data further 35.2% of the Eastern Band had households with incomes below poverty level, compared to 29.5% in Oklahoma (ibid. pp. 78 and 123).

A study of red cell antigens in Oklahoma Indians described in Kasprisin, et al. (1987), found considerable similarity in gene frequencies between North Carolina Cherokees described in Pollitzer et al. (1962) and Cherokees in Oklahoma. However, the Di^a antigen, which was found in Oklahoma, had not been identified in North Carolina. Kaprisin, et al. note that the lack of D^a on the North Carolina may have been due to the fact that that group was "relatively inbred population that may not be truly representative of the Cherokee people" (1982:6). Other explanations include sample selection in North Carolina, since the D^a antigen is rare in Oklahoma; different patterns of intermarriage; and possible introduction of the D^a gene may into the Oklahoma Cherokee from other Indian tribes in the area (ibid. p. 7).

Thornton's (1987) analysis of census data revealed notable differences in distribution of blood degree between the Eastern and Western Cherokee. From his analysis of the 1910 census, Thornton found that "Percentage of Cherokee full bloods varied greatly from Oklahoma to North Carolina: 5,919 or 20.0% of Oklahoma Cherokee were reported as full-blood; 934 or 65.4 % of North Carolina Cherokee were reported as full blood (ibid. p. 10). Furthermore, Thornton notes that fertility differences between full-blood and mixed blood marriages in Oklahoma (as reported in the 1910 census) suggest that "the full-blood population was decreasing in relative proportion to the mixed-blood population simply because of differences in reproductive behavior and outcome" (ibid. p. 18). Unfortunately no comparable data were available for North Carolina.

By 1930, census data still show a greater proportion of the North Carolina Cherokee to be full-blood in comparison to the Cherokee Nation (38.7 % in North Carolina compared to 17.3% in Oklahoma) (ibid. p. 23). Thornton cites data from Debo (1951) that about 75,000 persons in Oklahoma claimed to be Cherokee in the mid-1950s, about half of whom were probably at least 50% by blood degree (Thornton 1987:25). Since 1976 there has been no minimum blood degree specified for membership in the Cherokee Nation of Oklahoma, and the present roll includes "descendants of all those appearing on the Dawes Commission Rolls—including blacks and Whites" (ibid. p. 32).

It would appear that differences in diabetes rates between Eastern and Western Cherokee do not result from differences in the proportion of each population at risk for Type II diabetes, because census data show them to be essentially similar. However, higher incomes and the presence of a lower proportion of full-blood individuals may account for some of the difference in diabetes prevalence. A comparative study of diabetes prevalence and incidence in these two Cherokee populations would probably be well worth undertaking.

Distribution by Sex

Among the Eastern Cherokee, diabetes is 1.5 times more common in females. In the U.S. White population, however, male rates in several studies (i.e. Framingham, Massachusetts and Rochester, Minnesota) have been found to be higher than female rates until age 60, when female rates equal or exceed those of males (Krolewski and Warram 1985). Data from the San Antonio Heart Study show men to have higher rates of diabetes than women, especially when residing in "transitional neighborhoods" (as opposed to barrios and suburbs) (Stern et al. 1984). Incidence data from the Pima show that diabetes develops more frequently among males, except in individuals over 45 years having a body mass index (BMI) of 20-25 (a mid-range as defined by researchers) and persons age 25-44 years and 65-94 years having a BMI of 25-30 (Knowler et al. 1981:146). Unfortunately, researchers reporting these results do not provide any suggestions as to why this would be the case.

Stern et al. (1984) found that although diabetes became less common with increasing socio-economic status, prevalence of risk factors differed for men and women. That is, body mass index and the sum of subscapular and triceps skinfolds all declined with increasing socioeconomic status among women, but not among men. Age-adjusted diabetes prevalence among men was lower than that of women in the barrio, but higher in the suburbs. Stern et al. interpret these findings as follows:

> ...The sex differences in risk factor trends across neighborhoods suggest some factor which affects men and women differently is operative. We have previously shown that native

> American genetic admixture in Mexican Americans declines from barrio to suburbs but these genetic differences were seen equally in men and women (Garner et al. 1984). Similarly, one would presume that purely socioeconomic factors, for example the ability of upper income Mexican Americans to purchase more expensive foods, would affect both sexes equally. Thus, the present findings would seem to implicate cultural factors which would affect men and women differently (ibid. p. 849).

It is tempting to attribute the high diabetes prevalence among the Cherokee (and possibly also the Pima) to the high prevalence of the disease in females during childbearing years, since offspring of women who are diabetic during pregnancy have an increased likelihood of becoming diabetic as adults (Pettit 1986; Pettit et al. 1988). At Cherokee, 127 women ages 20 through 50 have Type II diabetes, but the number of these women at risk for pregnancy is unknown. Reasons for the unusual sex distribution in this population may include differential screening, or other factors yet to be determined. Prevalence statistics based on population distributions used by the tribal health office show diabetes to be more prevalent among women than men in every age group with female to male ratios of 4.26 in ages 15-19, 2.55 in ages 20-24, 1.3 in ages 25-44 and 45-64, and 1.4 in the over 64 age group. It should be noted that numbers are small in the first two categories, 5 and 10, respectively, so these differences may not be meaningful. Differences in the older age categories could be real differences, or possibly differences in mortality between males and females.

2. DEMOGRAPHIC ASPECTS OF DIABETES PREVALENCE

Blood Degree as an Isolating Mechanism

With Removal, genetic diversity among the Cherokees almost certainly decreased and was further augmented by a division of the tribe into "full-blood" and "mixed-blood" groups. As discussed in Chapter I, the main reservation at Qualla Boundary continued to absorb newcomers well into the twentieth century, while smaller communities such as those in the Murphy and Robbinsville areas, did not. Thus the effect in this decline in genetic variability was much greater in the latter.

Analysis of the Baker Roll shows that full-blood tended to marry full-blood and vice versa, thus maintaining the divisions. It is out of the population stratum described in the Baker Roll that most of the diabetics in the present population emerge. Furthermore, the full-blood population tended to be much less well off economically than the mixed-blood group, at least for many years following Removal. Geographic separation of the Cherokee County group, and their years of exclusion from tribal politics and services, tended to set that very mixed group even further apart from the main portion of the band living in Graham County and Qualla Boundary. This is evidenced by their relatively recent representation on the tribal council.

Both the middle-range quartiles of inheritance degree (25 through 74%) group are growing in number which seems to indicate that this polarization may be breaking down, however. This may support Thomas' (1958a) observation that more "White Indians" were tending either to chose Indian mates or to leave the reservation.

Data from the Baker Roll tend to indicate that blood degree may have acted as an isolating mechanism at that time (1924), possibly due to continuation of the clan system which regulated mate selection among full-blood Cherokee-speakers (Bloom 1945). However, as described by Thomas (1958a), it could also reflect some of the prejudice concerning White Indians that developed after World War I. Thomas (1958a) also has noted that although the terminology and some of the behavior remained into the 1950s, the lineage had largely disappeared as a basis for social organization (1958a:5). In addition, he observed "a sharp generational break between those born before 1900 and those born after 1900 with respect to clan knowledge" (1958b:32).

3. CHANGE IN DIABETES PREVALENCE

A comparison of current Eastern Cherokee diabetes data with Stein's study during the 1960s has shown that diabetes has increased in the Eastern Cherokee population. Farrell et al. (1989) have compared Stein's percentage of previously diagnosed diabetics to the number of diagnosed diabetics in the present population. (Those with abnormal glucose tolerance were excluded because of changes in diagnostic criteria for diabetes since Stein's study.) Despite previously described sampling problems, it is still worthwhile to make these comparisons. The overall percentage of diabetics increased from 17.2% to 25% with the greatest increases being in the 45 to 54 age group (14.9% to 21.7%) and the 55 to 64 age group (30% to 48.9%). It should be noted, however, that differences in survival rates may account for some of these changes. That is, more persons may be living to be 55 to 64 due to improved diabetes care.

4. THE "THRIFTY GENE HYPOTHESIS" AND THE EASTERN CHEROKEE

Researchers from the National Institute of Arthritis, Diabetes, and Kidney Diseases' long-term prospective study of diabetes in the Pima suggest that their research results are consistent with Neel's "Thrifty Gene" hypothesis. That is,

> ...If a 'thrifty genotype' were to occur anywhere it is not surprising that it would be found in these people who have subsisted for about 2,000 years by irrigation farming in the desert where the availability of water, and hence food was intermittent (Knowler et al 1983:113).

Both diabetic and non-diabetic Pima seem to have impaired ability to dispose of glucose and are thus insulin-resistant, yet fat metabolism appears to be sensitive to insulin even in Pimas with severe diabetes. From their research results they suggest that

> ...Pima Indians have resistance to glucose utilization and high insulin concentrations in blood, but they appear to have relatively normal sensitivity to insulin actions on fat stores. This could result in increased fat storage when food is available. Thus Neel's 'thrifty genotype' may mediate differences in sensitivity to insulin in various metabolic pathways. In times of alternating feast or famine, these differences in insulin sensitivity may have survival value by increasing fat storage. When food supplies are steady and abundant, as they are for the Pimas today, increased fat storage is detrimental, leading to increased obesity, insulin resistance and eventually diabetes (ibid.).

Since the "thrifty gene" hypothesis is predicated on an assumption of periodic food shortages, one may examine archaeological and ethnohistorical data for evidence of such shortages in these areas. Severe food shortages would have two major results for populations in which the "thrifty gene" remained: 1) acting as a selective mechanism to preserve the genotype in the population through differential survival, and 2) creating a population bottleneck in which genetic variability is decreased and the "founder effect" can occur. There is evidence that both occurred among the Cherokee.

Chapter V
Discussion

Archaeologists and others have expressed disagreement concerning the origins of modern Cherokee. Basically, the argument is whether or not the Cherokee arrived in the areas in which they were first found by Europeans relatively recently (about 1100 A.D.) or are descendants of earlier Mississippian peoples resident in the area (Hudson 1976:94). Dickens describes the late prehistoric period (1,000 A.D. to 1,450 A.D.) as follows:

> Late prehistoric cultural development in the Appalachian highlands, the probable heartland of the Cherokee, is characterized by: 1) settlement groupings in which several small villages were allied to a larger community that sometimes had a single platform mound; 2) a subsistence system in which hunting, gathering and agriculture were maintained with approximate equality; 3) little overt competition for space and resources; 4) no strong superordinate group within the larger social structure; and 5) long-term cultural continuity (1986:81).

Dickens further suggests that this pattern was expressed in three regional subcultures corresponding to the Lower, Middle, and Overhill Cherokee towns described in the historic period (1979:13).

Food shortages in these villages could result both from natural causes and from "cultural" causes (e.g. social disruption due to dislocation or from epidemics that made people unable to produce food). Evidence for food shortages comes from skeletal remains from archaeological sites and, in the historical period, from ethnohistorical accounts.

Skeletal remains from several late prehistoric archaeological sites such as Toqua (40MR6) in East Tennessee, show 32% of individuals ten years old or less, and 18% of individuals over ten years old, to have porotic hyperostosis (Parham and Scott 1980). The existence of this condition, which is characterized by lesions in the cranial vault, the eye orbits and some other sites, is often cited as evidence that affected individuals suffered from iron deficiency anemia.

Better evidence of possible food shortages resulting from epidemics of European-introduced diseases is found in ethnohistorical accounts (cf. Dobyns 1983; Ramenofsky 1987). When infectious diseases, e.g. smallpox, influenza, or typhoid, are encountered by people with no previous history of exposure to the disease, the result is particularly devastating. The result may not be so much from some sort of genetic or other biological deficiency in the persons affected, as from the fact that it hits the whole group all at once, and since no one has had the disease before, all are debilitated. Those who do not die of the disease itself often die of starvation because of the group's inability to feed itself, or from diseases contracted from unburied corpses (Crosby 1987).

There is ethnohistoric evidence that a "fat-thin cycle" probably existed among the eastern Cherokee into the historic period. In a letter written in response to a request by South Carolina's Governor Alen for food for soldiers building Fort Loudon, Connecort, chief of the Overhill Cherokee, replied that

> 'Tis true it is very hungry times here but what little we have we will share it with them and when there is a Want we will all want together, and believe we shall be poor but in the Fall of the Year we shall recover our Flesh and grow fatt again...(McDowell 1970).

This letter, dated March 20th, 1756, was written when stores of corn had run low and new crops had just been planted. These predictable food shortages became unpredictable and possibly more devastating during the American Revolution and in the years immediately following. In retaliation for forced cessation of land because of their loyalty to the British during the American Revolution, the Lower Town Cherokee, in alliance with the Creeks, practiced "guerilla warfare" against frontier settlers and suffered severe retaliation:

> ...Time after time the white frontiersmen sent invading armies to burn the Lower Towns, destroy their crops, slaughter their livestock, burn their granaries. But the Chickamaugans always melted into the forest before them, returning later to rebuild the towns, reconstruct their homes and farms, continue their raiding parties. Enraged frontier settlers refused to distinguish between the friendly Upper Towns and the guerrillas in the Lower Towns. Invading peaceful Cherokee villages, they provoked many of them to join the guerrillas. Eventually, almost every Cherokee village, of which there were close to sixty, was ravaged, often more than once. The population of the tribe was cut from an

> estimated 22,000 in 1770 to 14,000 in 1774. In 1809 there were only 12,395...(McLoughlin 1984:5-6).

Severe uprooting of families during this period further stressed resources:

> ...More than two-thirds of their families were uprooted and forced to move -- some two or three times. Resettling into already overcrowded and disorganized towns, they placed a severe strain upon limited resources, depleting precious supplies of grain and livestock. Before they could start new fields and harvest a crop, these displaced families often reduced whole communities to virtual starvation (ibid. p. 9).

Among the Eastern Cherokee, only a part of the population made the drastic change from a productive agriculture to relying exclusively on nature's providence. The remainder continued subsistence as they had before Removal. Most of the Cherokee that hid in the Snowbird Mountains to escape Removal lived in Graham and Cherokee counties. Duane King relates an account of these events by a woman who was a small girl at the time when troops hunted down fugitive Indians in order to remove them to Oklahoma.

> ...They escaped during the night and waded in the river so their trail could not be followed. Subsisting on roots and nuts they traveled only at night and hid under bushes by the water during the day. They arrived at their hideout in the North Carolina mountains cold, wet, and hungry, with badly bruised numb feet on the seventh night of their escape (King et al. 1979:171).

Another group of Cherokee, those living at Cheoah, fifty miles west of the Qualla Boundary in Graham County, were also not removed by the soldiers at Fort Montgomery, near Robbinsville. These Cherokee, about two hundred in number, were able to purchase about 1,235 acres of land in the names of three White men in order to remain in North Carolina (ibid. p. 177). This group formed the nucleus of today's Snowbird community. Finally, the Oconoluftee Cherokee remained marginal to the Cherokee Nation, becoming "Citizen Indians" (citizens of the state of North Carolina), and thus not subject to removal (ibid. p. 166).

According to King, the "Citizen Indians" lived on land that, because it was more mountainous, was less valuable than that of the Cherokee further west. Because farming was limited by the availability of flat, tillable land, they were more dependent on wild foods. Evidence for assortative mating indicates that differences within these groups were maintained for many years, thus separating a group - those of high degrees of Indian inheritance - that have a greater potential to develop diabetes.

Like the Eastern Cherokee, the Pima underwent a sudden population decline, but for different reasons. In their case the population decline was more recent - 1870 - and resulted from their inability to irrigate due to White settlers' diverting water from the Gila River for their own use. Many Pimas starved to death, and only those able to live on desert resources were able to survive. According to one Pima, "That is the reason the doctors say we're so big. We're the ones that survived."

5. PROSPECTS FOR INTERVENTION

Given what has been established thus far concerning the distribution of diabetes the Eastern Cherokee, what are the prospects for intervention that would result in a lower prevalence of this disease? Goodman suggests that anthropologists should be particularly aware that social and cultural processes do not necessarily translate into individual health promotion and that we should be less interested in medical interventions, than in socio-cultural interventions. Socio-cultural interventions should have more general application and be more relevant to policy research (1986:239). One socio-cultural question worthy of investigation in this regard is whether there are barriers to medical services, and if so, what they might be. Even though health care is provided free of charge to those eligible, there are still transportation problems that probably affect many users of the health service. Ethnic and social class differences between health care providers and clients may also hamper provision of care in some instances. These differences should probably be assessed in relation to persons at high risk of developing diabetes because they hamper prevention efforts.

In the long run, the best strategy may be to deal with diabetes prenatally. The occurrence of diabetes in pregnancy is relatively high at Cherokee - about three times the national average (Farrell 1990). Efforts to track children of women having diabetes during pregnancy have begun by the Cherokee IHS in order to target these children for aggressive preventive efforts, particularly weight control. This may involve service adjustments in provision of prenatal care and cooperation between IHS and local hospitals that deliver Cherokee women. If good data can be obtained on the number of children born and how many are at high risk of becoming diabetic, it may be possible to predict the future diabetes load among the Cherokee in years hence. Indeed, Neel (1982) suggests that the best way to test the "thrifty gene" hypothesis may be to examine glucose metabolism in children before they develop elevated serum insulin levels and obesity. Such a study should involve children without with or without family histories of diabetes and with "varying degrees of predisposition to NIDDM" (ibid. p. 290).

Applying findings from this study in the health care delivery setting is problematic because it involves transferring the idea of being at risk for diabetes in an epidemiological sense to a risk that is perceived and acted upon as an "unmeasured risk" by the individual (Goodman 1986). The real danger in communicating this risk is, according to Goodman, the fact that individuals probably feel they have no personal control over the risk, and may tend to put themselves and their condition totally in the hand of health care providers (ibid. p. 234). In the case of a number of chronic diseases, including diabetes, control of the disease, and even getting the disease in the first place are often in the hands of the individual and the degree to which he or she controls his or her own lifestyle. For a number of minority groups who have historically had little control over their own destinies in other areas, solutions to this problem may require extraordinary efforts on their part.

CHAPTER VI

CONCLUSIONS

This dissertation has described the prevalence of diabetes among the Eastern Cherokee, its distribution in the present population, and certain demographic and social factors that have contributed to its persistence over time. The focus of this study is variation within the tribe, rather than comparisons of overall rates to those of other Native American groups, but certain of these comparisons are of interest because of theories related to origins of genetic susceptibility to the disease.

Data from Cherokee history illustrate the importance of events and social processes in shaping diabetes prevalence in this population. If diabetes is indeed related to the proportion of "Indian genes" in a population, then it is important to be aware of these processes in comparing diabetes prevalence rates for different tribes because these events may differ from tribe to tribe. Among the Cherokee, two mechanisms, creation of a population bottleneck, and assortative mating based on blood degree, appear to be significant factors in determining the distribution of diabetes in this population. The latter factor is particularly interesting in light of ethnographic descriptions of the consequences of the distinction of "full-blood" and "mixed-blood" described in recent times.

As noted by Thomas (1958a), these are social distinctions that structure interactions between various groups in Cherokee society and may or may not be related to actual blood degree as described on tribal rolls. However, these distinctions appear to have had real significance with respect to mate selection during the 1920s when the Baker Roll was taken, as there is clear segregation by blood degree on that Roll. During the 1950s Thomas observed that "Indian" appearance was becoming a factor in mate selection as well. To the extent that blood degree reflects some degree of genetic reality and has some relation to "Indian" appearance, it appears that social relations are reflected in the genetic structure of the population. It appears to be a similar process as that described for the Japanese (cf. Hulse 1967).

Tompkins' (1980) finding that obesity, as measured by skinfolds thickness, does not appear to be related to degree of Indian inheritance among the Cherokee is interesting in light of Terry's (1982) study showing the high rate of obesity among Snowbird women. Since that group has remained historically separated from the main center of population it is possible that the tendency to become obese may be a biological characteristic of that population. Thus heritability of obesity combined with genetic predisposition to diabetes may contribute to the high prevalence of diabetes in that community. Driscoll's (1982) interesting finding of variability among WIC participants in three different clinics could not then be interpreted as difference due to variations in Indian inheritance among the clients at each clinic, but to variations in inherited obesity.

The fact that insulin resistance seems to be the primary condition necessary for the development of Type II diabetes, and that it is probably inherited, means that there are most probably "diabetes-prone" families among the Cherokee. These are probably families who are in the higher Indian inheritance group that has been historically separated and among whom there is a familial tendency to become obese. This is evident from the fact that though obesity may not be related to Indian inheritance, diabetes occurs more frequently in that group. New research data on progression to diabetes show that obesity exacerbates insulin resistance and thus may hasten the onset of diabetes:

> ...there is general agreement that the development of NIDDM is most likely among those who have the more severe degrees of IGT. Among the Pima Indians among those with IGT, those who have higher glucose levels, the higher fasting insulin levels, but lower two-hour post-load insulin levels are most likely to decompensate to diabetes. Also, those who are more obese and who are 35 to 54 years of age are most likely to decompensate than either younger or older subjects (Bennett et al. 1988:8).

Chapter VI
Conclusions

Comparison of more recent data from two other groups, the Mississippi Choctaw and Three Affiliated Tribes, who have a similiar history of population fission, suggest a similar process may have occurred among these groups. The Mississippi Choctaw, like the Cherokee, remained in the east when most of their population was moved west during Removal in 1830-31. Prior to removal, people of the mixed-blood population "often married, subsequently forming a social circle apart from their pure-blood Indian relatives" (Wells 1986:48) and it was this group that favored Removal. According to Swanton (1946:80), only 2,000 to 3,000 remained in Mississippi. A second Removal beginning in 1903 moved 1,462 of 2,534 full-blood Choctaws (as identified by the Dawes Commission) then living in Mississippi to the Choctaw Nation in Indian Territory. Thus only 1,072 were left living in Mississippi in 1907 (Roberts 1986:94-97). According to Roberts, most of those leaving Mississippi at that time "..had been involved in missionary and educational programs, suggesting that those Choctaw who left for the Indian Territory were among the more highly educated" (ibid. p. 103). The impact of Removal on the remaining Choctaw was severe:

> The diminution of numbers was accompanied by major changes in the direction of Mississippi Choctaw society...The state of Mississippi, responding to the decline in Choctaw population, also abandoned its efforts to provide schooling for the Choctaw. The communities were therefore badly shaken when the more educated Choctaw departed for the Indian Territory. Those who remained in Mississippi fell into another period of isolation. Only after 1981 and the establishment of a federal agency for the Choctaw would the Indians regain the direction and momentum that they had in the two decades before the second removal (ibid. p. 108).

Today the tribe of just over 4,000 is said to be more than 90% full-blood (Peterson 1979:142-43) and most of the mixed-blood families have been absorbed into surrounding communities:

> Today several thousand recognized full-blood Choctaw live in Mississippi, and several multiracial isolated groups claim Choctaw lineage. Most early mixed-blood families, however, simply accepted roles in the white communities that sprang up

> around them. Their survivors are today a large proportion of the modern population. The experience of the Choctaw in Mississippi parallels that of the Chickasaw, the Creeks in Alabama, and the Cherokee. All of the southeastern tribes underwent much the same acculturation process, and all suffered the eventual consequence of tribal disunity and removal (Wells 1986:53).

Diabetes rates among the Choctaw (from Strauss and Johnson 1989) are much higher than that of the Eastern Cherokee, yet lower in the younger age groups as shown in Table XI. Differences in diabetes prevalence between in the younger age groups may be due to the Cherokee data including three Type I diabetics, two of whom occur in the first age category and one in the second.

The Three Affiliated Tribes (Mandan, Arikara, and Hidatsa) of Fort Berthold, North Dakota are similar to the Cherokee and Choctaw in that they are "remnant" groups. However, the North Dakota tribes are survivors of a severe smallpox epidemic rather than Removal. That epidemic in 1837 killed over 90% of the Mandan (leaving only a population of 125) and over 50% of the Arikara and Hidatsa (Brousseau 1979; Spencer and Jennings 1977:318). Today over 40% of the total population are full-blood Indian, according to IHS records (op. cit.) Recent data show the Three Affiliated Tribes to have diabetes rates higher than the Cherokee (Brousseau 1989): 32.5% of the population age 45 through 64 compared to 20.3% in the Eastern Cherokee, and 33.5% in the 65 and over age group compared to 22.2% in the same age group of the Eastern Cherokee. Diabetes in these groups, as well as among the Cherokee, affects a relatively small portion of the total population (8.4%) yet affects that portion severely.

Table XI Diabetes Prevalence: Mississippi Choctaw and Eastern Cherokee

Age Group	Mississippi Choctaw (per 100,000)	Eastern Cherokee (per 100,000)
0-14	45	3,621
15-44	8,929	3,621
45-64	40,752	16,917
65 or more	36,530	17,080
Total Population	10,132	7,558

Choctaw data from Strauss and Johnson (1989)

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Data presented here on other tribes, although limited, suggest that comparisons of diabetes rates between tribes may only be meaningful when demographic processes and characteristics are taken into account. Now that more is known about diabetes prevalence in a greater number of tribes, it may be possible to more finely attune techniques of descriptive epidemiology in order to undertake some comparative studies. Such studies could control for such variables as Indian inheritance and socioeconomic status, for example. Even within the Eastern Cherokee themselves it may be possible to compare the occurrence of diabetes among families with a long history of residence at Qualla Boundary to occurrence in those families arriving more recently.

The research described in this dissertation has combined the techniques of epidemiology with ethnohistoric and cultural data on the Eastern Cherokee to provide a broad picture of diabetes occurrence in this group in accordance with Dunn and James' conception of the relationship between the two disciplines. This combination is an exciting that is only beginning to be fully explored and diabetes research seems to be the perfect area in which to test ways in which the two disciplines together can contribute to a better understanding of this disease.

Because this dissertation is largely concerned with processes that may have perpetuated a "thrifty genotype" as proposed by Neel (1976, 1982), it is perhaps appropriate to end with his own conclusions about its place in diabetes research:

> ...All these speculations may be utterly demolished the moment the precise etiologies of NIDDM become known. Until that time, however, devising fanciful hypotheses based on evolutionary principles offers an intellectual sweepstake in which I invite you all to join (Neel 1982:290).

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APPENDIXES

APPENDIX I

GUIDELINES FOR GLUCOSE TOLERANCE TESTING

PURPOSE: The glucose tolerance test is performed for the purpose of establishing the clinical diagnoses of diabetes mellitus or gestational diabetes. The OGTT is not necessary if the fasting plasma glucose is greater than 140 mg/dl on more than one occasion.

METHODS: The type of OGTT done will vary according to the purpose of the test. Urine GLucose values do not need to be measured.

I. DIAGNOSIS OF DIABETES IN ADULTS

A. Patient to be fasting 10-14 hours
B. Draw fasting blood sugar
C. Give 75 grams of standard glucose solution for nonpregnant adults (3/4 of 100 gram bottle)
D. Draw samples at 1/2, 1, 1 1/2, and 2 hours.

II. DIAGNOSIS OF DIABETES IN CHILDREN

A. Patient to be fasting 10-14 hours
B. Give patient 1.75 g/kg of oral glucose solution (maximum 75 grams)
C. Draw samples at 1/2, 1, 1 1/2, and 2 hours

III. SCREENING FOR GESTATIONAL DIABETES

A. Patient does not need to be fasting
B. Give patient 50 grams of standard glucose solution
C. Draw blood sample one hour later

Iv. THREE HOUR GLUCOSE TOLERANCE TEST FOR GESTATIONAL DIABETES

A. This test is done on all patients with a positive screen for gestational diabetes (above 135)
B. Patient is to be fasting 10-14 hours
C. Give patient 100 grams of standard glucose solution
D. Draw blood samples fasting 1, 2, and 3 hours

INTERPRETATION OF TEST RESULTS

I. DIABETES IN ADULTS - Patients meet one of the following criteria:

A. A random plasma glucose level of 200 or greater PLUS symptoms of polydipsia, polyuria, polyphagia, and weight loss
B. A fasting plasma glucose of 140 on at least two occasions
C. FBS less than 140:
Two hour sample and at least one other sample > 200 on OGTT on two OGTT tests

II. INPAIRED GLUCOSE TOLERANCE IN ADULTS - Patients meet all the following:

A. Fasting glucose less than 140mg/dl
B. A 2 hour glucose value between 140 and 200 mg/dl
C. One other value during OGTT greater than 200

III. GESTATIONAL DIABETES IN PREGNANT ADULTS

A. Screening test with 50 gram is positive if value above 135.
B. If screenig test is positive a three hour 100 gram GTT should be ordered.
C. The diagnosis of gestational diabetes is made if two plasma glucose values equal or exceed the following:

Fasting	105
One Hour	190
Two Hour	165
Three Hour	145

IV. DIAGNOSIS OF DIABETES IN CHILDREN - Patients must meet one of the following:

A. Random glucose above 200 plus classic symptoms of polyuria, polydipsia ketonuria, and rapid weight loss.
B. FBS over 140 on two occasions PLUS 2 hour sample and one other sample above 200 on at least two occasions during OGTT.

V. DIAGNOSIS OF IMPAIRED GLUCOSE TOLERANCE IN CHILDREN - Patients should have both the following criteria:

A. FBS less than 140
B. A two hour glucose value greater than 140 on OGTT

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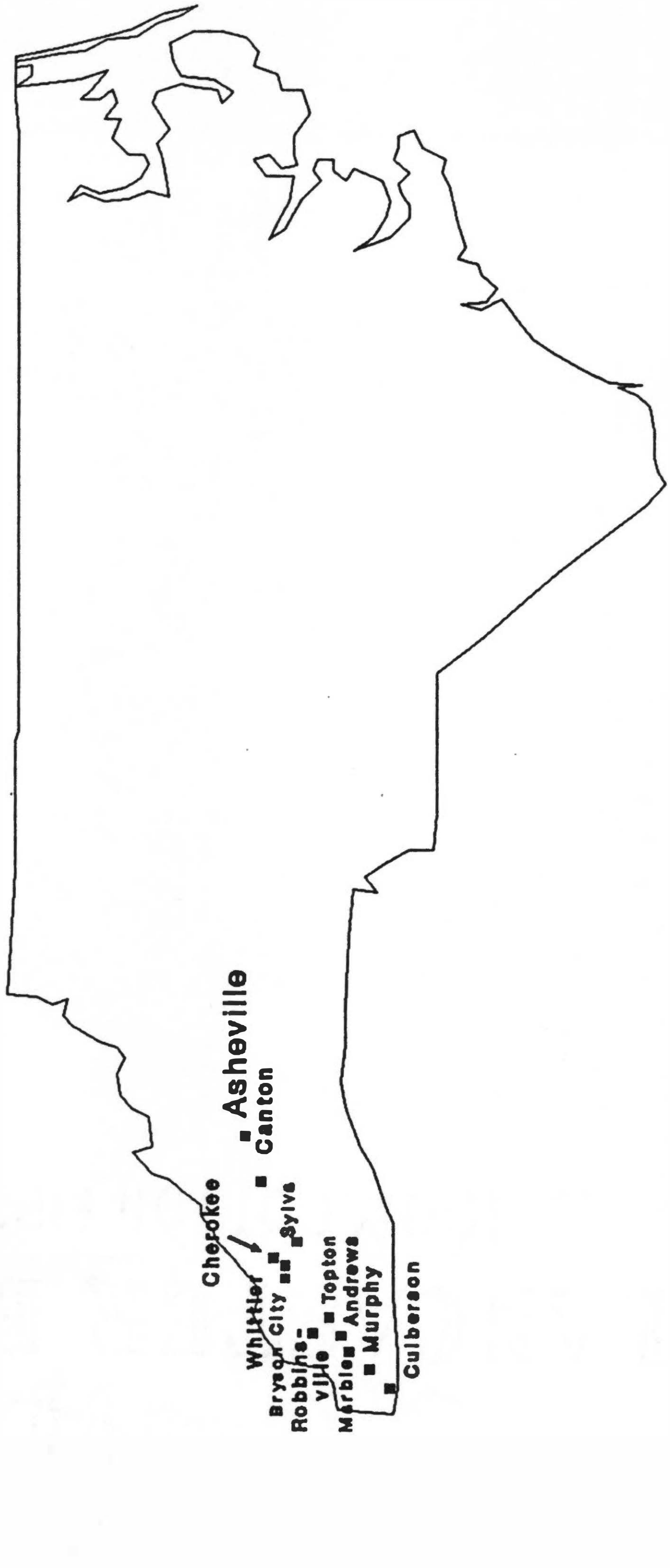
APPENDIX II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VITA

Patricia Ann Quiggins was born in Louisville, Kentucky, where she attended elementary and high school and college. Following graduation from Western High School she attended the University of Louisville for two years. After spending several years living in Canada, where she became interested in archaeology and participated in an archaeological project, she returned to Louisville to complete her undergraduate degree. While attending the University of Louisville, she was employed by the Planned Parenthoold Center of Louisville, Inc. and by the University of Louisville Archaeological Survey. Her experience at the Planned Parenthood Center piqued her interest in medical anthropology.

After receiving her B.A. degree in 1975, Pat worked for a year at the Planned Parenthood Center for one year before entering graduate school at the University of Kentucky. At the Universty of Kentucky she pursued her interest in medical anthropology, primarily under the tutelage of Dr. Marion Pearsall, who introduced her to the area of Appalachian Studies. While at the University of Kentucky, Pat taught several courses in anthropology and was a graduate assistant in the Department of Behavioral Science in the College of Medicine. She received her M.A. degree from the University of Kentucky in 1983 and completed much of her Ph.D. coursework there before transferring to the University of Tennessee in 1986.

While attending the University of Tennessee, Pat was employed for one semester as a graduate assistant before she was employed at the Oak Ridge National Laboratory, where she worked in various aspects of computing. After leaving the Laboratory, she spent two and a half months living on the Eastern Cherokee Reservation completing a project for the Indian Health Service on renal complications of diabetes. She received her Doctor of Philosophy Degree in August 1990.